A 000 587 511 7
UC SOUTHERN REGIONAL LIBRARY FACILITY

THE MONTREAL ELECTRICAL HANDBOOK

726 T
Sel

Compliments of

LOCAL RECEPTION COMMITTEE

BOSTON MASS.

Electrical Engineers' Handbook

THE MONTREAL ELECTRICAL HAND-BOOK

Being a Guide for Visitors from Abroad Attending the International Electrical Congress, St. Louis, Mo. September, 1904.

Montreal

Published under the auspices of

The American Institute of Electrical Engineers

1904

SIH

Entered according to Act of the Parliament of Canada, in the year 1904, by WILLIAM ARCHIBALD DUFF, at the Department of Agriculture.

CONTENTS

PAGE

CITY OF MONTREAL 9

McGILL UNIVERSITY 44

MONTREAL LIGHT, HEAT & POWER CO. 58
R. M. Wilson, B.Sc.

CANADIAN PACIFIC RAILWAY CO. 73
Henry Goldmark, C.E.

ELECTRICAL EQUIPMENT CANADIAN CANALS 85
Louis Herdt, Ma E., E.E.

THE BELL TELEPHONE CO. 100

CANADIAN WESTINGHOUSE CO 107

CANADIAN GENERAL ELECTRIC CO. 115

SHAWINIGAN WATER & POWER CO. 121
Wallace C. Johnson, Mem. Am. Soc. C. E.

ALLIS-CHALMERS-BULLOCK LTD. 143
H. A. Burson, B.Sc.

DOMINION COTTON MILLS 148
F. H. Leonard, Jr., E.E.

LOCOMOTIVE AND MACHINE CO. 158
John Murphy, M.A.I.E.E.

MONTREAL STREET RAILWAY CO. 167
W. G. Ross, Esq.

OTTAWA AND VICINITY. 181
A. A. Dion, M.A.I.E.E.

NIAGARA DISTRICT 195
R. A. Ross, E.E.

LOCAL RECEPTION COMMITTEE

R. B. Owens, Esq., D.Sc. - - - Chairman.

J. E. Aldred	Wallace C. Johnson
W. F. Angus	John Kennedy
W. R. Baker	R. S. Kelsch
J. A. Baylis	Edgar McDougall
F. E. Barbour	C. H. McLeod
K. W. Blackwell	J. M. McCarthy
H. T. Bovey	Frank W. Morse
H. A. Burson	R. D. Mershon
W. A. Duff	Ernest Marceau
W. F. Dean	Wm. Peterson
Alfred Collyer	F. R. Redpath
E. A. Evans	Hazen Ritchie
P. G. Gossler	E. F. Sise
H. S. Holt	W. G. Ross
L. A. Herdt	R. A. Ross
George Janin	W. McLea Walbank
C. A. Johnson	R. M. Wilson

Henry D. Bayne, Esq. - - General Secretary.

MONTREAL of all cities on the continent of North America possesses an unique interest for the visitor from the old world. Founded in 1641 under the leadership of Paul Chomedy de Maisonneuve, it is perhaps not so old as some of the cities of the new world, but as a storm centre, as an outpost of civilization, as a point round which the conflict of savage and civilized swung, there is no other place with so romantic a history unless indeed it be Quebec.

Maisonneuve Monument.

Canada owes its discovery to the Cabots—father and son, who sailed under the patronage of Henry VII. of England, but the first settlements and colonization of the country were carried on by the various ministers and officers of the French Crown.

As early as 1534 Jacques Cartier, a venturesome Norman, native of St. Malo, sailed up the Gulf of St. Lawrence

and planted a cross on a bold headland in token of the formal annexation of the country by France. The following year Cartier returned with a better equipped expedition in five vessels of considerable size for those days. On the site of modern Quebec he found an Indian village known as Stadacona. The inhabitants received him kindly, and by their tales of the country to the West fired Cartier to ascend the river, accompanied by some of his followers, and several of the friendly Indians, they began the long boat journey which at last brought him to the Island of Montreal. At that time a large Indian town of 1,500 or more people nestled under the shadow of Mount Royal standing approximately where Dominion Square and St. Catherine Street are to-day. To this first visit we owe the name of our city. The beauty of the mountain behind the village of Hochelaga prompted Cartier to name it Mont Royal, from which we have our modern name, Montreal.

The autumn season was drawing to a close and the little expedition were not equipped to stand the discom-

Caleche.

fort of a winter in the open. Consequently they dropt down to Quebec and re-embarked for old France.

A third voyage was made by Cartier in 1540. This time he ascended the river for some distance above Montreal, but was again forced to retire by the advancing season and once more withdrew to France without making any serious attempt at colonization.

From time to time other expeditions came to Canada, but nothing of importance is to be recorded before 1611 when Samuel de Champlain, the founder of Quebec, and the first great French colonizer, established a trading post on the Island of Montreal, near the spot where our Customs House now is. Champlain was the first leader to identify himself with the new country and to lend himself heart and soul to settling and colonizing it. His relations with the Indians were fortunate. With them

Chateau Frontenac—Quebec.

he travelled over much of the country and with them he established the Canadian fur trade. He was for years the great source of wealth to the Colony. Quebec was his capital, however, and in and around Quebec was the most considerable settlement of French colonists.

An Old Mill.

Some 30 years later one de la Danversiere, working in concert with Jean Jacques Olier, later and better known as the founder of the Sulpician Order, conceived the plan of establishing a permanent settlement on the Island of Montreal with the double object of engaging in the profitable fur trade and of carrying on active missionary work among the natives. A number of kindred spirits were gathered together and in 1641 an expedition under the leadership of Paul de Chomedy de Maisonneuve sailed from France to the New World.

The landing place of Maisonneuve.

On the 18th of March of the same year the little band landed on the Island of Montreal and began their work by building an altar and celebrating mass on the spot now known as Place Royale. Thus was Montreal founded.

Amongst these pioneers were a few priests whose establishment grew into the present Seminary of St. Sulpice. Jeanne Mance, the devoted girl who has raised a monument to herself in the Hôtel Dieu, the oldest hospital of the City, of which she was the first directress, superin-

tendent and nurse. Shortly afterwards Marguerite Bourgeois joined the colony and began the work which has grown into the teaching order of the congregation of Notre Dame.

All three of these institutions have exercised a very considerable influence on the growth and life of our City, and all three are closely identified with its career.

As time went on the settlement of Ville Marie grew, aided in large measure by the arrival of new colonists from France. In 1672 the town had grown so steadily that a new church, Notre Dame, after Notre Dame de Paris, was built for the spiritual needs of the inhabitants. So well was the work done that the old building was in use continuously, until the opening of the present edifice in 1830, some 150 years later.

The continual conflicts with the Iroquis Indians are amongst the most important events which mark the growth of the town. For many years they attacked the

"Bonhomme" Mugwando, a typical Indian guide.

French settlers, and their Huron and Algonquin allies, with a regularity that was only matched by their relentlessness and savage cruelty.

One name stands out prominently on the roll of those who perished in the defence of the colony,

Old Windmill on Lower Lachine Road.

The old LaSalle Homestead.

Dollard, to give his name its most usual rendering, in company with sixteen brave young colonists, and helped at first by a handful of friendly Indians, held at bay for several days, a band of eight hundred Iroquois warriors at the Long Sault of the Ottawa River. No one of them survived, but their heroism undoubtedly saved the struggling colony from a carefully premeditated attack, which would otherwise have resulted in its total annihilation.

There appear to have been powerful interests at work in France, for the succeeding years show large additions to the population, wealth and permancy of New France. Soldiers were sent out to protect the colonists, settlers were induced to leave their homes in France, and live stock, implements and seeds were sent out from the Mother Country.

As the colony grew the conflicts with the Indians became less frequent and less serious, and profitable sources of trade were discovered and developed.

"Relics of Antiquity."

In 1663 the first step towards self-government, granted by the establishment of the Superior Council at Quebec. The Council consisted of a Governor-General, the Bishop of Quebec (Monseignor de Laval) five councillors and a secretary. Later a new office was created, the holder of which was called the Intendant, and who acted as a comptroller, representing the interests of the King. This Council possessed very considerable powers, executive, judicial and legislative, in short, the complete power of government in the colony.

About this time too we see the appearance of the seigneurs, a sort of feudal lord of the manor. They held large tracts of land all along the banks of the St. Lawrence as grand vassals of the King, with very wide discretionary power within their seignories. The original grantees were almost all retired soldiers who had served

Street Scenes during the Floods of the Eighties.

in the army of occupation, and of whom the Home Government sought to make permanent settlers by giving them a real stake in the progress and prosperity of the colony. The success of the plan is shown in the fact that all along the banks of the St. Lawrence to-day we find families who trace their ancestors directly back to officers of the old French army, and who occupy, if not the very house, at least the estates of their great-great grandfathers. Indeed it was only in 1854 by act of the Parliament of Canada that the Seignories were abolished and the tenants of censitares of the manors were provided a means of comuting their annual rent and becoming the proprietors of the land they occupied.

During her prolonged struggle with France, the attention of England was turned to Canada. Not only did the English Crown claim prior right of discovery, in virtue of the voyages of the Cabots, but the French settlements had for years been a thorn in the side of the New England colonists.

In 1758 a great expedition was organized, destined to overpower the French in Canada, to crush out their influence and bring North America under the British

Dominion. The following year saw the fall of Louisburg, the stronghold of Cape Breton Island, and the especial menace of the New England towns. Shortly after General Wolfe, after a particularly long and wearisome investment, succeeded in placing his troops on the historic Plains of Abraham. The French under Montcalm were completely routed and the Citadel of Quebec, the key of Canada. fell into the hands of Great Britain. The death of Wolfe at the moment of victory left the command of the forces to Generals Amherst and Murray, two of his ablest lieutenants. On the 8th September of the same year their efforts were brought to a fruitful conclusion by the signing of the capitulation of Montreal by Vaudreuil, the then Governor of Canada. The whole of the French possessions passed to Great Britain, subject to the conditions that those French subjects who so wished should be allowed to sail for France, while those who remained were to be guaranteed the enjoyment of their language, religion and civil laws. That these guarantees were respected and loyally appreciated is shown, not only in the fact that the French Canadians stubbornly resisted every attempt of the rebellious American colonies to enlist their sympathy and support against Great Britain in 1774, but that some of the most useful members of the Canadian contingents in South Africa were descendants of the very French Canadians who had fought at Quebec and Montreal. For a time

Wolfe and Montcalm Monument—Quebec.

the government of the City was necessarily military. The policy of the government, however, was to make the colony self governing, and from time to time various means to that end were adopted. The influx of Anglo-Saxon blood also stimulated the growth and enterprise of the country. In 1778 we find the establishment of *The Gazette* which still publishes its daily issue. By the beginning of the 19th century the City had outgrown its ancient limits, and the part outside the fortifications was rapidly becoming greater than the older portions within. English institutions were beginning to grow up, and 1805 is marked by the laying of the foundations of the first English Cathedral, Some four years later a steamboat service was inaugurated between Montreal and Quebec by John Molson. The "Accommodation," the original boat, is said to be pioneer of steam navigation; a remarkable production, if the claim is justified, for the young colony.

In 1817 the growing needs of the inhabitants caused the establishment of the Bank of Montreal, an institution of

Bank of Montreal.

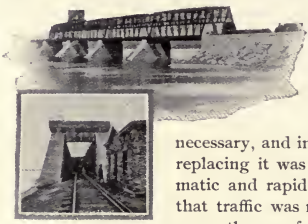
which we are justly proud. With a capital of $12,000,000 and a rest fund of $6,000,000 the Bank stands to-day the fifth strongest financial institution in the world. Within the following year or so James McGill, a successful fur trader and merchant, bequeathed a large sum of money

and a considerable estate for the founding of the University which bears his name.

In passing, it is interesting to note the number of Scotchmen who have at one time or another occupied prominent positions, and been identified with the growth of the city. In the church, in education, in financial, railway, steamship, and commercial enterprise generally, the leaders have time and time again been bearers of some honoured Scotch name. One of the latest, and not by any means the least of these, is Lord Starthcona, the present Canadian High Commissioner in London, President of the Bank of Montreal, and sometime President of the Canadian Pacific Railway.

The City was incorporated, and its first City Council was selected in 1832, with Jacques Viger as its first Mayor, Tentative improvements had been made in the harbour, and the new Council adopted the policy of extending and further equipping it. Their successors have carried on the work until to-day. Our City, a thousand miles from the sea, is one of the largest ports of North America. The ever increasing and spreading population began to need transportation facilities, nor were they long in coming. Various means of communication grew into use, steamers, sailing vessels, stages, and finally the parent of Canadian railways, was projected from Montreal to Portland. In the course of time the Company grew into what is now the Grand Trunk Railway System, with its 4,177 miles of track. To the enterprise of its first directors we owe the Victoria Tubular Bridge, which was opened to traffic by King Edward VII, then Prince of Wales, on the 25th of August, 1860. The work of Robert Stephenson, the great English engineer. This bridge for

many years held first place amongst the engineering works of the world, and was the admiration, not only of ourselves, but of every engineer in the old world as well as the new. A commemorative medal, struck for the opening, gives the following details:—"it consists of 23 spans 242 feet each, and one in the centre 330 feet, with a long abutment on each bank of the river. The tubes are 18½ to 22 feet high, 16 feet wide, and weigh 9,044 tons, supported on 24 piers containing 223,000 tons of stone. Extreme length two miles, cost $7,000,000." Fine as this structure was, traffic has so increased of late years that a new double track bridge of greater capacity became necessary, and in 1898 the work of replacing it was begun. So systematic and rapid was the progress that traffic was not interrupted for more than a few hours, and the new Victoria Jubilee Bridge was formally opened in the fall of 1900 by the Duke of York. The present structure is of the modern open-work steel model, known as the American truss bridge. It has a double track and extension roadways, is supported by the original piers to which some masonry has been added, is 66 feet 8 inches wide, forty to sixty feet high, and has a total length of 9,144 feet, including the approaches.



Victoria Tubular Bridge.

The view gained by the traveller seated at the car window of the train that crosses this bridge into Montreal on a summer evening is particularly fine and difficult to equal in its peculiar charm. The mountain which forms the background to the City is half hidden in the purple haze of departing day, the dark green of its foliage standing out in relief against the glowing sunset sky. Close lies the city with factory, mill and house dimly dis-

tinguishable, their rawness softened and hidden by the gathering twilight. In the foreground the swift running St. Lawrence, the masts and funnels of the shipping, and the two central towers of Notre Dame. The darkness deepens, electric lights one after the other, twinkle and scintilate the whole river front. The city itself glitters with its thousand unwinking eyes, and beyond and above all the black mass of the Mountain rises in its still grandeur like a silent watcher of the night.

The old Wharves on the River-front.

Montreal was for some years the capital of the Canadas, and the presence of the Governor and a British Garrison added no little to its gaiety. Political disturbances followed the destruction of the Parliament Buildings, led to the removal of the seat of Government to Ottawa, which became the Fedeal capital when the various provinces were united in 1867, by the British North America Act.

The first tramway made its appearance in 1865, and a more or less satisfactory service of horse cars was kept up

until 1892. In that year, the present Street Railway Co. was organized to electrify the old system, and the tram horse passed away permanently some three years later.

Ruins of Fort Senneville.

1880 is marked by the beginning of negotiations for the construction of the Trans-continental Railway which the Federal Government was pledged to build. The object sought was to bring the Eastern and Western Provinces closer together, to make their union more practical and more real. It needed no little pluck and foresight to undertake the construction of a railway 3,000 miles in length through a territory only known in its most general and crudest outline. Happily men were found, and the Canadian Pacific Railway with its four daily trains from Atlantic to Pacific stands as a monument to their courage and energy.

The development of electricity in and around the City is spoken of elsewhere. Even in this field, where the old World has done so much, we feel that we still can show the stranger something of considerable interest.

The glory of Montreal is its mountain, though the unthinking call it a hill. It is only seven hundred feet in height, and covers an area of four hundred and thirty acres. It was acquired by the City from private owners in 1874, and since that time the energy expended on it has been chiefly in the direction of preventing inroads upon it by private corporations, and not altogether with

success. It has fairly well resisted all efforts at improvement since it was laid out by Mr. Frederick Law Olmstead, the same who so successfully dealt with Central Park in New York. In a little book upon the subject, he reveals his plan for the development of the property: namely, to follow along the lines which nature had already laid down, and bring to light its half hidden but characteristic beauties. This he has succeeded admirably in doing. Even his names are suggestive and artistic, though they have long ago fallen into disuse, if indeed they ever were commonly known.

Royal Victoria Hospital.

The most characteristic approach is by University street, along Pine Avenue, past the Royal Victoria Hospital, and thence, by an easy and graceful serpentine driveway, to the Upper Reservoir at Cragsfoot.

The ascent is continued westward through the forest or Underfell, through the cliffs, and at the western end one sees at the left, rolling grassy slopes known as the Glades, and on the right, a pine covered knoll which, from the abundant growth of ferns, is termed the Brackenfell. By this circuitous route the summit, or Upperfell, is reached, and from Piedmont in the north, one may look out toward St. Jean-Baptiste village over the level plain of Côte Placide. This wide expanse is known as Fletcher's Field, over which, for twenty-three years, the members of the Royal Montreal Golf Club teed and drove and putted until its very stones were dear to them.

From these various elevations, views are seen which each one may fit with words according to his desire.

Shooting the Lachine Rapids.

Away to the westward, the valley of the Ottawa opens out, and the river itself, splitting upon the Island of Montreal, sends its waters upon either side to mingle with the St. Lawrence. Lake St. Louis is spread out like a sea, and the Lachine Canal gleams like a ribbon of silver, and, upon occasion, one may see the leap and sparkle of the Rapids.

Looking to the south across the river, a level plain is seen with scattered villages and pointed peaks, Laprairie at the extreme right and Varennes on the left.

The mountains rise from the level like miniature Fusi-Yamas, being in order from the west, Monnoir, Shefford Rougemont, Yamaska, Belœil and Montarville. Away in the distance, dimly outlined are the Green Mountains of Vermont, and the Adirondacks of New York. Towards the north and west at some little distance there is a conical peak, and in the hollow and slopes between it and Mount Royal is the resting place of the dead, Catholic and Protestants, religiously divided even in death.

Ascending the farther hill by a toilsome path is the Way of the Cross, with shrines at regular intervals for contemplation of the events which once transpired on some such way as this. Upon the summit, one beholds three crosses bearing their burdens allegorical of the central fact in the doctrines of the Church. Upon the first day of the week, pilgrimages of men and women, led by their gowned priests, "make the way," stopping at the shrines for admonition and prayer, and as they toil upward, one may hear from afar the confused murmur of chanting

Stabat Mater dolorosa,
Juxta Crucem lacrymosa,
Dum pendebat Filius.

Of smaller parks Montreal has not a few.

Place d'Armes is a small enclosure surrounded by several noble buildings. The parish church of Notre Dame, with the Seminary of the Sulpicians, occupies the southern side. The Bank of Montreal with its classic front faces the church, and upon either hand are large buildings for commercial purposes. The most notable

feature of the Place d'Armes is the statute erected in honor of Sieur Chomedy de Maisonneuve, the founder of Montreal. He is represented in bronze, in the costume of the 17th century, holding a fleur-de-lys banner. The granite pedestal shows the inscription: "Paul de Chomedy de Maisonneuve, Fondateur de Montréal, 1642." It rests upon a fountain, and displays bas-reliefs representing: Maisonneuve killing the Indian chief, the founding of Ville-Marie, the death of Lambert Closse, defending his enclosure near St. Lambert Hill; the

Viger Square.

heroic death of Dollard, who fell with his companions at the Long Sault of the Ottawa, and saved the colony. At the four corners are life-size bronze figures, representing an Indian, a colonist, with the legendary dog Pilote, a soldier and Jeanne Mance, all finely done under the direction of P. Hébert.

Jacques Cartier Square fronts the river and is adoned with a column and statue of Lord Nelson, erected in 1808. It is now fallen into decay, but a project is afoot for its restoration. Into this square the traffic from Bonsecours market overflows, and it has lost all the dignity of a public place. At the head of this square, Frontenac burned four Iroquois in 1696, with good success.

Victoria Square is in the centre of the city, at the foot of Beaver Hall Hill, and contains a good bronze statue of Queen Victoria, of colossal proportions, by Marshall Wood.

Dominion Square occupies the site of the old cemetery, and traces of its original function are continually coming to light though many of the bodies were removed in an emblematic way. The Square is a pleasant place, and acquires dignity from the buildings on either side: the Canadian Pacific Depot, the Windsor Hotel, and on the

Dominion Square.

other side Cathedral of St. James. Here have been erected the ice palaces when Carnival was king. Near the centre of the Square is a structure, and within it, upon examination, one may find a figure in bronze of the late Sir John A. Macdonald. The figure itself is of commanding

An Ice Palace.

proportions with a reasonable degree of harmony in its parts, but the canopy, with its obscure or meaningless adornments and trifling decorations, disguises the value of the figure. The edifice is flanked by two guns acquired from the Russians at Sebastopol.

St. Helen's Island, at the foot of the current, is a small island called by the name of Helen, wife of Champlain, the first European woman to visit Canada. The English government acquired it from the Barons of Longueuil for a military depot and station. There is yet upon the Island a battery of guns and barracks. The place is

prettily wooded, and at times many secluded spots are to be found. It well warrants a visit, and is easily reached by steamer from Jacques Cartier Square.

The Old Blockhouse.

The visitor finds a considerable source of interest in the churches with which Montreal is so well provided that a stranger of curious wit remarked, a boy could not throw a brick without breaking a sacred window.

St. James Cathedral, from "down-town."

The Cathedral of St. James has an imposing situation upon Dominion Square. It is erroneously called the Cathedral of St. Peter, because it is a reproduction of St. Peter's at Rome, modified to suit the exigencies of the Canadian climate. For example, the roof is sloping to throw off the snow. This noble edifice was projected by the late Archbishop Bourget, whose statue is at the door of the cathedral, in 1852, when his church and

palace on St. Denis street were consumed in the great fire of that year. The work was commenced in 1868, and is yet unfinished. Apart from the plan, the exterior is hard and gloomy in appearance. The dome is a noble adornment and a salient feature in the architecture of Montreal. Its height with the cross is two hundred and fifty feet, and its diameter ninety feet. The facade and portico are unfinished. The plan is cruciform, after the manner of

Notre Dame Church.

its prototype, the tribune and ends of the transept being rounded. The total length is three hundred and thirty feet, the breadth at the transept two hundred and twenty-five feet, the height to the roof tree, eighty feet. The interior when finished will be upon the model of the Italian churches. The large brick structure adjoining it, is the palace of Archbishop Bruchesi.

The parish Church of Notre-Dame faces the Place d'Armes. It is a plain, stately edifice of a late Gothic style, built of grey stone, in 1824, by James O'Donnell. The present site was occupied by a church built in 1672, a long low structure with a pointed roof. Notre-Dame is one of the largest churches in America, being two hundred and fifty-five feet long and one hundred and thirty-four feet wide, and capable of containing fifteen thousand persons. There are two towers two hundred and twenty-seven feet high, provided with an elevator, and from the summit a notable view may be obtained. They contain a chime of ten bells which are rung upon special occasions. There are three others, one, "le Gros Bourdon," the largest bell in America, weighing fifteen tons. The interior is florid and tasteless in its decoration, but the wood carving is good. The organ was built at St. Hyacinthe in 1890. Behind the choir is the richly adorned "Lady Chapel."

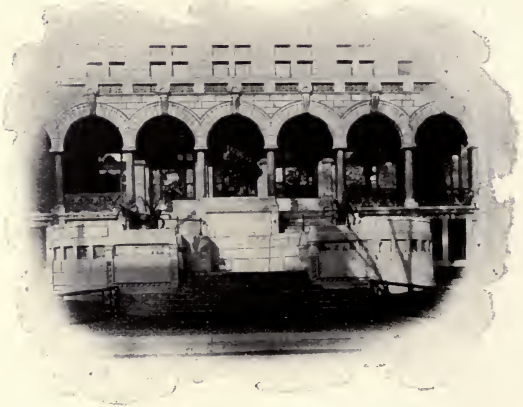
Seminary of St. Sulpice.

Adjoining the Church is the Seminary of St. Sulpice, erected in 1710 and now used for the offices of the Order. As in the days of Charlevoix, it is "a stately, great and pleasant house, built of freestone, after the model of that of St. Sulpice at Paris; and the altar stands by itself, just like that at Paris."

Notre-Dame-de-Lourdes, on St. Catherine street, is the only church in Canada in which all the interior decoration is meant to illustrate one central idea, in this case the dogma of the Immaculate Conception. M. Bourassa, the artist, was stimulated to this effect by the declaration in 1854, of Pius IX, that this dogma was of faith. The style of architecture is Byzantine and Renaissance, in harmonious proportions, and within and without the effect is one of unity and force.

Notre-Dame-de-Bonsecours dates from 1673, when it was founded by Marguerite Bourgeois. The present edifice dates from 1771, and several times was in danger of being swept away by the tide of commerce at its base. It has been sorely mishandled by the renovator.

The Church of the Gesu, on Bleury street, with St. Mary's College adjoining, is the abode of the Jesuits. They returned to Canada in 1847, and erected the present church in 1864. Members of this order were the first to

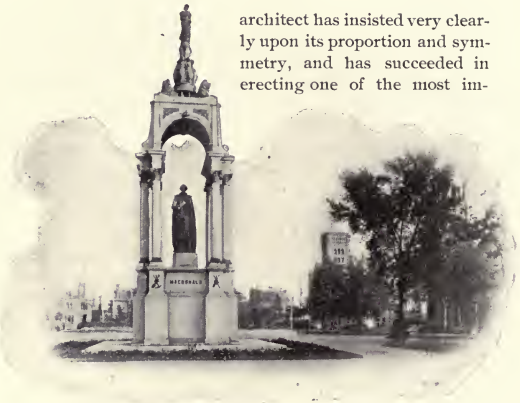


Entrance to Laval University.

establish missions in Canada, and on account of their trials affords the most romantic reading of history. Individual priests penetrated the wilderness and lived and died often in hideous torment amongst the savages of the Iroquois confederacy. At the time of the conquest they were expelled from Canada, and their estates confiscated. Up to five years ago, their revenues were devoted to educational purposes, when, under arrangement, their estates were restored to the order. The church is one hundred and ninety-four feet long, ninety-six feet wide, the transept one hundred and forty-four feet, and the nave ninety-five feet high. The frescoes are in grisaille, grayish tints imitative of bas-reliefs, a very effective decoration for the interior. The evening music is very fine, and an admirable sermon in English is often preached, which attracts many non-adherents of the Roman communion.

Custom House.

Amongst the churches of Montreal, the Anglican Christ Church Cathedral holds first place in correctness of style. The style chosen is Early English, and the



Macdonald Statute—Dominion Square.

architect has insisted very clearly upon its proportion and symmetry, and has succeeded in erecting one of the most important architectural units in America. Its conception is due to Dr. Fulford, the first resident bishop of Montreal, and his memorial on the east side is much admired. It resembles the Martyrs' Memorial at Oxford. The church is in the form of a Latin cross. The total length is two hundred and twelve feet, transept one hundred feet, height of spire two hundred and twenty-four feet, nave sixty-seven feet. The material of which it is built is Montreal limestone faced with Caen, Normandy, white sandstone, which seems to be too soft for this climate, though it weathers to a very delicate tone of colour. There is no attempt at interior decoration, except in the staining of the glass, which is well done, especially the northern window and those of the transept. Other features are the seats of the choir, and the capitals of the columns carved to imitate Canadian flowering plants. The chapter house, an octagonal building with broken outlines, adds to the general effect. Behind the

Bonaventure Station—Grand Trunk Railway System.

cathedral is the bishop's court and rectory, and synod hall. In spite of, or perhaps by reason of, the correctness of the design and the adherance to it, the edifice somehow lacks the true cathedral feeling.

St. George's Church, Anglican, on Dominion square, is a very dainty piece of building after the manner of the thirteenth century Gothic. One notes the following features : the stone porch, the spire two hundred and thirty feet high, lately completed, the wide span of the roof, and the freedom of the nave from pillars. The church was erected in 1870, of limestone and olive sandstone.

The Church of St. James the Apostle, on St. Catherine street west, is a pleasing little edifice. It contains a chime of six bells which ring with good effect. One admires the pulpit of Egyptian marble and Caen sandstone, and the stalls of carved butterwood.

The principal Presbyterian churches are St. Andrew's (Church of Scotland), on Beaver Hall Hill ; St. Paul's, Knox, American and Crescent, on Dorchester street ; and Erskine Church on Sherbrooke street.

St. James is the chief of the Methodist churches. It is situated on St. Catherine street; it is elaborate in design, and within, the arrangement is of a very modern kind.

There are a few other public buildings which deserve a passing notice.

The Natural History Society's Museum was established in 1822, and incorporated in 1827. One of the charter members, J. J. Day, Q.C., is still living. It contains about seventeen thousand specimens of various kinds in its building on University street. On the staircase landing is an interesting collection of Montreal birds, also a small series of monkeys and marsupials, and three cases of British birds. Canadian mammals are in the centre of the main hall; cases on the left contain the geological collections, those on the right a collection of shells. The wall cases contain a fine series of Canadian birds, and also a collection of foreign ones. In the gallery, are minerals and fishes, and also the "Ferrier" collection of Egyp-

Chateau de Ramezay.

tian antiquities ; the walls are decorated with weapons of various kinds, and amongst the miscellaneous objects there are several of quite historic interest. The museum also possesses cabinets of botany and entomology, and a small collection of skulls, and of birds' eggs.

Within the Château de Ramezay, on Notre Dame street the chief features are : the Elgin Gallery, containing many rare historical portraits and relics, and especially the bell of Louisbourg ; the "Court Room," hung with battle scenes of the British Empire ; the "Council Chamber," where Montcalm, Charlevoix, Benjamin Franklin, Benedict Arnold, and the famous governors Vaudreuil, Haldimand and Elgin, have sat ; the "Salon" ; the "Parloir" ; the "Old Vaults," in one of which Franklin's printing press was set up ; the "Kitchen," with its great fire-place ; the "Bakery." As a building, the Château is of small architectural importance ; its interest being derived from its great historic associations, and the light thrown by its construction upon the methods and manners of New France.

Sleighing on Sherbrooke St.

The Fraser Institute Free Public Library was founded by Mr. Hugh Fraser, a citizen of Montreal who died 15th May, 1870, leaving considerable property to trus-

tees. After paying certain legacies, they obtained an act of incorporation. The will was contested, and carried to the Privy Council, but was sustained. The Institute was opened to the public, October 15th, 1885. The Library contains about thirty thousand volumes. The Institute has been the recipient of many generous donations and bequests.

The Art Association Building, on Philips square, is an imposing structure well suited for its purpose.

In the collection of the Art Association, of Montreal, there are one hundred and sixty-three oil paintings and forty-two water colors. The most important oils are; The Crown of Thorns, by W. A. Bouguereau; the Huntsman, by A. W. Kowalski; A Woodland Brook, by Bliss Baker; La Rosée, by E. Lansyer; Sand Dunes, by Tholen; Dutch Interior, by Peter de Hoocke; Sunday in the Backwoods, by T. Faed.

In the Tempest Bequest, there are good examples of C. Troyon, Jacques Henner, James Moris and Pelouse; of water colours, Mauve, Israels, Jas. Moris, and de Venne.

There are also many notable pictures in private hands, some of which are owned as follows:

Sir Donald A. Smith—Turner, Henner, Jules Breton; Sir W. C. Van Horne—Monticelli, Rousseau, Daubingy, Corot, Delacroix; Hon. G. A. Drummond — Troyon, Daubingy, Duprés, P. de Hoocke, Franz Hals; R. B. Angus—Gainsborough, Rowney, Rembrandt, Dagnan-Bouveret, Swan, Reynolds, Monticelli; James Ross—Rembrandt, Corot, Troyon, Millet, Fortuny, Teniers; E. B. Greenshields—Turner, Morris, Ryder; W. J. Learmont—Turner, Reynolds, Swan, Gainsborough.

Though Montreal is the commercial metropolis of Canada, and its people as a whole are engaged in the chase of "the Almighty Dollar," for there is practically no leisure class, the lighter side of life is not by any means neglected. The people are particularly fond of outdoor sports of all kinds, as indeed the numerous clubs in and around the city show.

The Montreal Hunt Club is the oldest Hunt on the

continent, and their club house and pack would suffer by comparison with very few others.

The Royal Golf Club, which owns a beautiful home and links at Dixie, has the proud distinction of being the Pioneer Golf Club of Canada, and the first to bear the name Royal.

Finish of a Skating Race for the American Championship on the M. A. A. Rink.

The Royal St. Lawrence Yacht Club, the Forest and Stream (a country club), the Metropolitan, Outremont, Westmount and Victoria Golf Clubs, are amongst Montreal's most popular summer clubs.

Each of the summer resorts in the vicinity of the city too has its Boating and Tennis Clubs and its Golf Links. Lake St. Louis, a wide expanse of the St. Lawrence, some miles above the city, is lined with summer cottages, and its surface on a fine afternoon is crowded with the white sails of numerous smallcraft. The Scawanhaka-Corinthian trophy for small yachts has for several years now found a resting place in the Royal St. Lawrence Yacht Club, and the sailors of Lake St. Louis are quietly confident that it will remain there for many more. In winter, too, when the Lake is covered with two or three feet of ice, an occasional yachtsman may be seen piloting his ice boat at railway speed.

Lacrosse, the Canadian national game, holds an important place in the hearts of the sport-loving public. There are several clubs in the city, chief of which are the Shamrock Amateur Athletic Association, and the Montreal A.A.A.

Baseball too attracts its crowds to Atwater Park, where a team of American professional players wear a Montreal uniform and play under the name of our city.

But it is in winter that the out-of-door Canadian finds his chiefest delight—skating, tobogganing, snow-shoeing,

Ice-yachting on Lake St. Louis.

skiing, driving, are all exceedingly popular. It is indeed a sight on Saturday afternoon and evening, to see the warmly clad crowd of tobogganers, snow-shoers, and "skiiers," on the slopes of Mount Royal. The air is

Hockey Match at the Victoria Rink.

crisp to intoxication, and one shouts with the very joy of living.

Winter, too, is the time of that king of all sports, ice hockey. It is impossible to give one who has never seen it any idea of the game. The speed, the endurance, the

A Tramp Round the Mountain.

skill displayed, are marvellous. From end to end of the rink the rubber disk travels at lighting speed, and the players are after it continually. The Canadian is almost

The Westmount Rink.

born with skates on his feet ; indeed, one would think so when one has seen one's first game of hockey.

The different Athletic Associations, chief of which are the M.A.A.A., and the S.A.A.A., have under their protection various clubs for Football, "Sockey," and "Rugger," hockey, lacrosse, snow-shoeing, skating, track and cross country running. There is, in short, no lack of sport of all kinds, and no lack of opportunity for outdoor life in the great majority of our Canadian people's lives.

McGill University.

ALMOST alone among Canadian colleges and universities, McGill University owes its origin to a private endowment. Its founder, the Hon. James McGill, from whom the University takes its name, was born on the 6th of October, 1744, in Glasgow, Scotland, where he received his early education and training. Emigrating to Canada before the American Revolution, he engaged in the North West Fur Trade, then one of the leading branches of business in Canada.

Approach of McGill University.

Subsequently he settled in Montreal, and, in partnership with his brother, Andrew McGill, became one of its leading merchants, distinguished for his public spirit and his exertions for the advancement of the city. He was lieutenant-colonel, and subsequently colonel of the Montreal City Militia, and in his old age, on the breaking out of the American War of 1812, he became brigadier-general and was prepared to take the field in defence of his country. He also represented the West Ward of Montreal

in the Provincial Legislature, and was afterwards a member of the Legislative and Executive Councils. Cultivating and enjoying the society of the few men of learning then in the colony, he took a special interest in the establishment of an educational system in the Province of Quebec. By his will, bearing date the 8th January, 1811, more than two years before his death, which happened on the 19th December, 1813, he bequeathed his property of Burnside and a sum of £10,000 in money to found a college in a provincial university, the erection of which had already been provided for by the generosity of the British Government. Three leading citizens of Montreal were among the trustees appointed under his will, who were directed to convey the subject property of the bequest to the Royal Institution for the Advancement of Learning, a body, which, in 1802, had been incorporated by the Legislature "for the establishment of Free Schools and the advancement of Learning" in the Province of Quebec. The conditions upon which the property was to be transferred to the Royal Institution for the Advancement of Learning were, mainly, that that Institution should, within ten years after the testator's decease, erect and establish on his Burnside estate "an University or College for the purposes of education and the advancement of learning in this Province," and that the college or one of the colleges in the University, if established, should "be named and perpetually be known and distinguished by the appellation of McGill College." Owing to persistent opposition by the leaders of one section of the people to any system of governmental education and to the refusal by the Legislature to make the grants of land and money which had been promised, the proposed establishment of the Provincial University by the British Government was abandoned.

In so far as the McGill College was concerned, however, the Royal Institution at once took action by applying for a Royal Charter. Such a charter was granted in 1821, and the Royal Institution prepared to take possession of the estate. But, owing to protracted litigation

this was not surrendered to them till 1829. Commencing then the work of teaching with two faculties—Arts and Medicine. The record of the first thirty years of the University's existence is an unbroken tale of financial embarrassment and administrative difficulties. The charter was cumbrous and unwieldy, and unsuited to a small college in the circumstances of this country, and the University, with the exception of its medical faculty, became almost extinct. But after thirty years the citizens of Montreal awoke to the value of the Institution, which was struggling in their midst. Several gentlemen undertook the responsibility of its renovation, and, in 1852, an amended charter was secured. The Governor-General of Canada for the time being, Sir Edmund Head, became interested in its fortunes, and in 1855, with the advent of a new Principal, an era of progress and prosperity began.

Under the regime of Dr. Dawson, McGill University became the leading educational institution in Canada. Dr. Dawson, at this time Sir William Dawson, retired in 1895, and was succeeded by the present Principal, Dr. William Peterson, who, for the previous thirteen years had been head of the University College of Dundee, and under whom the University continues to make the same satisfactory progress.

The total number of students in the University are now about 1,150. The amount of endowments, exclusive of buildings and equipment, is between three and four million dollars.

The faculties are now four in number—Arts, Law, Applied Science and Medicine. At the beginning, however, Arts and Medicine went side by side. Then Law, represented by Hon. W. Badgley, Q.C., "Lecturer in Law, no salary, but a fee from each student attending his lectures of $2.00 per term," came in. It took this Faculty a good many years to reach its present state of efficiency. One great obstacle stood, and still stands in its way. The system of law established in the Province of Quebec differs from that elsewhere in vogue on the continent. Elsewhere the common law of England is followed.

Here we have French Civil Law. Hence the number of students in law at McGill will always be small. The fees will never be sufficient, or nearly sufficient to defray all the expenses of a competent staff. Hence endowment is required. Owing to the generosity of Sir William Macdonald, the Faculty is now in a very strong position, both financially and in other respects.

Faculty of Applied Science—The Faculty of Applied Science, now independent, agressive and successful, started in life as a branch of the Faculty of Arts, but seperated therefrom in 1878. The number of students in 1878 was twenty-eight, and last session three hundred and twenty-two. The present efficient state of this Faculty is owing almost entirely to the munificent donations on the part of its benefactor, Sir William Macdonald, Chairman of the Board of Governors. The Faculty comprises the

Macdonald Physics Building.

departments of Electrical Engineering, Civil Engineering, Mechanical Engineering, Railroad Engineering, Recent Development, Mining, Metallurgy, Surveying and Geodesy Architecture, and Practical Chemistry. Dr. H. D. Bovey is the Dean. The Department of Physics is directed by Professor John Cox, and Professor Ernest Rutherford,

the latter being well known from his brilliant work on radio-activity. The Chemistry Department is under the charge of Professor B. J. Harrington and Professor J. W. Walker. The Chemistry Building is very completely equipped with apparatus for research work and demonstration, and recently, to meet the demand in instruction in Mining and Metallurgy, a department in that branch of Engineering has been equipped and generously endowed by Sir William Macdonald. Dr. J. B. Porter is in charge of Mining, Professor Alfred Stansfield, of Metallurgy.

View of McGill University.

The Mechanical Engineering Department, under Professor R. J. Durley, has an elaborate equipment of experimental engines of all kinds—steam, gas, oil, hot air, etc., being represented by their various types. It is also well fitted with numerous types of boilers.

Faculty of Medicine.—The Faculty of Medicine of McGill University is the direct outcome and continuance of the body known as the Montreal Medical Institution, which was organized as a Medical School in the years 1823-24.

In the year 1829 the Montreal Medical Institution became by a formal Act of the Governors of the Royal Institution, the Medical Faculty of McGill University. In 1844 the number of students in the Medical Faculty was fifty; in 1895-96, 419, with 90 graduates. In 1903-04, 395 students were registered.

The Faculty at first had their premises on St. James Street; then on St. George Street, near Craig Street, where they remained till 1845. From 1845 to 1851 they occupied the central part of the present Arts Building. Then they removed to the City in Cote Street, where they remained till 1872. The need of extension was again felt and the front block of the present Medical Building in the University grounds was provided by the Governors. In 1885 this building was again found to be inadequate, and an addition was built at the rear. Owing to the larger classes, and the necessity for more laboratory teaching, the lecture rooms and laboratories soon became insufficient in size and equipment to meet the requirements of the Faculty. The late Mr. John H. R. Molson, with timely generosity came to the aid of the Faculty, and in 1893 purchased property adjoining the College grounds, and enabled the Faculty to erect new buildings and extensively alter and improve those already in use.

In less than five years the extension of the practical laboratory work and the increase in the number of students and teachers, made an enlargement of the building almost imperative. Before, however, the want of space and equipment was very seriously felt, Lord Strathcona generously provided means to meet the requirements, and new buildings to the value of over $100,000 were formally opened by the Prince of Wales on his visit to Canada in 1901.

Faculty of Arts—The Faculty of Arts has 194 men students, and 159 women students, and 47 in the affiliated colleges. Special provision is made for the education of women, and for this purpose, in 1899, the Royal Victoria College, built by Lord Strathcona, was opened. Thereby the opportunity for residence and college life is given to women students of McGill University, and a share in the advantages of college life is offered also to the non-resident women students of the University, who are also students of the Royal Victoria College.

A Musical Department was also organized, which has now developed into the Conservatorium of Music, to be opened next September.

Among the general University Buildings may be mentioned the University Library, and the Peter Redpath Museum.

The Peter Redpath Museum was erected in 1882 by the benefactor whose name it bears. It occupies a commanding position at the upper end of the campus, and besides its central hall and the other rooms devoted to the collections, contains a large lecture hall, theatre, class rooms and work rooms.

The Library is housed in the fine Romanesque building erected in 1893, by the late Mr. Peter Redpath.

Dignified and convenient as originally designed, it has recently been improved and greatly enlarged by the liberality of Mrs. Peter Redpath. It now possesses ample accommodation for three hundred and fifty readers, of whom fully one hundred can be provided for in the Seminary rooms and special studies.

Electrical Engineering at McGill University.

THE Electrical Engineering Department is located in the Macdonald Engineering Building. The undergraduate course is maintained through a curriculum covering four years. Of these the first two are spent in the study of mathematics, the physical side of electricity, draughting, etc. The last

The Macdonald Engineering Building, McGill University, Montreal.

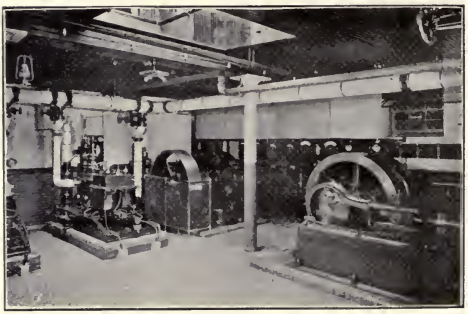
two years are devoted to the study of applied electrical engineering.

The Electrical Department is under the charge of Dr. R. B. Owens ; Assist. Professor L. A. Herdt and Mr. T. P. Jackson as Senior Demonstrator. There are also a number of laboratory assistants, a mechanician and complete service staff.

The electrical laboratories are five in number, as follows :—A direct current dynamo laboratory ; an alterna-

ting current dynamo laboratory; a laboratory for special research work, a high tension laboratory and a standardizing laboratory. In addition to this the institution has a complete service plant and battery room in the basement of the engineering building. These different laboratories are well shown in the accompanying illustrations.

The service plant proper consists of five boilers suppling steam to four direct connected direct current generators. Two horizontal engines connected to 2-75 K. W., 125 volt generator; one Williams engine connected to a 30 K. W. 125 volt generator and another Williams engine connected to a 50 volt 30 K. W. generator used as a booster for charging the service batteries. This battery, the largest in Canada, has a capacity of 300 kilowattt an hour at the normal eight hour discharge. In the service

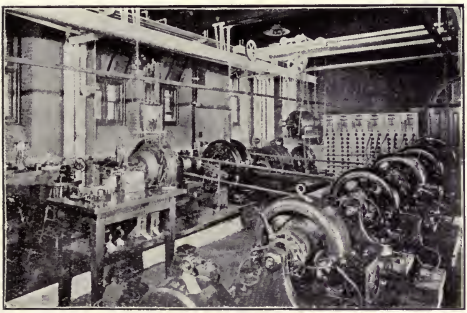


Engine-Room of the Service Plant of McGill University.

plant besides the generator booster and feeder panels there is a distributing Switchboard with integrating wattmeters in each of the many power and light circuits used in the different buildings of the University.

The Dynamo Laboratories.—One of the most notable features of the dynamo laboratories is the fact that there are no overhead belts and shafting and that all the

machinery is movable, being easily shifted from place to place. Nothing is permanently fastened so that any possible combination of the elements present may be made in a few moments and very simply. This is accomplished by means of a two-ton hand-travelling crane by which any machine may be picked up and moved to any place or taken out of the room altogether if desired. Before



The Alternating-Current Dynamo Laboratory, McGill University.

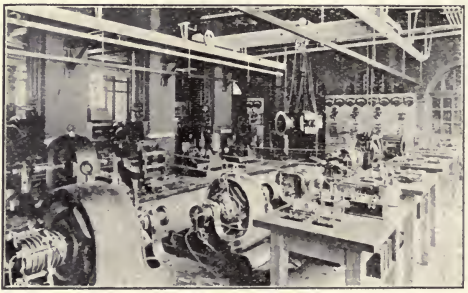
the equipment of the laboratories some six years ago, the dynamos were all driven by overhead countershafts. This arrangement was apt to cause fluctuations of speed in one machine to become evident as variations of load took place in another. The arrangement now is such that each generator is driven by a séparate motor capable of independent speed control, while a sufficient number of supply circuit are wired through the laboratories to enable this to be done with the maximum of convenience. All of the machines are mounted on benches about 15 inches high. Under each of these benches is a concrete wire duct containing heavily insulated supply circuits. At intervals of five feet each of these supply circuits is tapped to insulated bayonet connections. Any generator

or motor can be connected at once to any supply or other circuit or connected up in any way that is desired for circulating power, test, etc.

Besides the main supply circuits from the generating stations the laboratories are equipped with three separate sets of experimental batteries of 61 cells each 25 amperes normal discharge rate. These can be thrown either in parallel or series on any current of the laboratories given, 110, 220 or 330 volts, besides end cell regulation as desired. The switchboard for these batteries is shown in the background of the cut of the direct current dynamo laboratoy.

In the background of the cut of the alternating current laboratory which is on the opposite side to the D. C. laboratory, the two being separated by a row of posts, is shown the distributing board. This board is so arranged that any source of supply that is available can quickly and conveniently be connected to any supply circuit or so that any supply circuit and transversing circuit may be connected together so as to allow practically any combination of current and machines to be made.

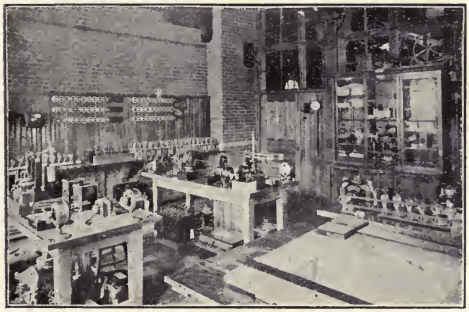
In the A. C. laboratory the same general arrangements that obtain in the D. C. laboratory is carried out. In this



The Direct-Current Dynamo Laboratory.

department the A. C. generators are operated by individual D. C. motors, and each motor is provided with a differential winding with means of varying the number of effective turns in order to hold the speed constant over a wide variation of load. This laboratory is equipped with an overhead crane similar to the one on the D. C. side. It is the intention of the faculty to equip another D. C. laboratory this winter, and leave the present dynamo laboratory entirely free for A. C. work.

In the system of teaching employed in the laboratory work class demonstrations are almost entirely done away with, there being at present no lectures given on the laboratory work. In the laboratories the men are divided into groups of three or four men each, and the particular work on which any group is engaged is explained to them in the laboratory by the professors and demonstrators, and the whole work is carried out under the direct supervision of the professors. To each group to whom a special piece of work in the laboratory is assigned, there is supplied a motor, a generator, and, if necessary, a separate source of supply, with means of

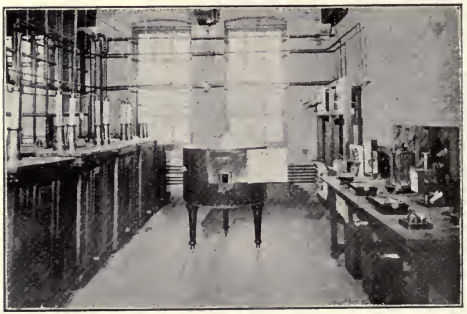


The Laboratory for Special Electrical Investigations McGill University.

controlling and accurately measuring the speed of the motor, and means of absorbing the power generated (consisting either of wire or water rhoostats), and a special portable table and leads to facilitate the work. In this way each group of students is independent and can in no way interfere with the work of another group.

The Laboratory for Special Research Work—This Laboratory is supplied with direct current of all voltages, and with alternating current of all voltages and any frequency, and is used for testing meters, transformers, small machines, fusewire, etc.

The High Tention Laboratory—This Laboratory has been fitted up for the study of alternating currents of very high pressures. Its equipment consists of 4-10 K.W. 50,000 volt transformers, and one 20 K.W. insulating transformer. It is supplied with a switchboard, regular heads, a Stillwell regulator, and a Kelvin electrostatic voltmeter reading from 15,000 to 150,000 volts. To this



The High-Tension Laboratory, McGill University.

equipment has recently been added—a 10 K.W., A.C.D.C. set; a Dynamostatic machine, and a 10,000-20,000 volt transformer for special research work. This equipment

has recently been removed to a fire-proof concrete room which was built specially for its reception.

The Standardizing Laboratory—This Laboratory is equipped for standardizing all kinds of electrical apparatus. Its equipment includes—Weston standard voltmeter, ammeters, and wattmeters; Kelvin balances reading among them from 0 to 600 amperes; electrostatic

The Laboratory for Standardizing Electrical Instruments, McGill University.

voltmeters; potemtiometers, etc.; also a Ewing's hysteresis tester and permeability bridge. In this laboratory from 200 to 300 college instruments, besides many outside instruments, are standardized every year.

The Montreal Light, Heat & Power Company's Systems.

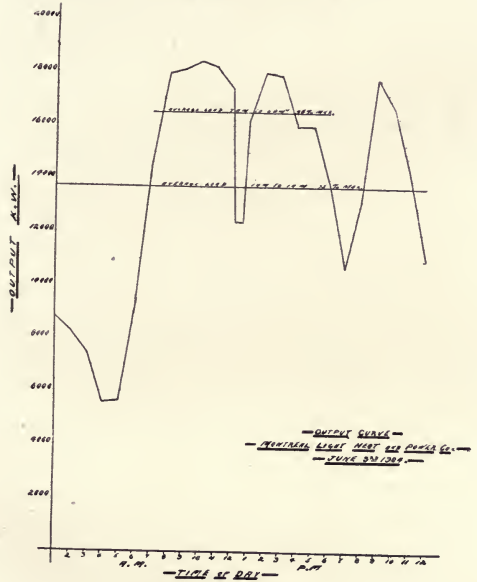
THE City of Montreal holds at the present time rather a unique position in the Electrical World, consuming as it does more electrically transmitted water power than any other City in the world, as well as being the largest electrical centre in the Dominion of Canada. Power is supplied from three generating stations, known as the Lachine, Chambly and Shawinigan Power Houses, located at distances of 5, 17 and 85 miles respectively from the City. The voltages used for transmitting energy over these distances are 5,000 volts, 25,000 volts and 50,000 volts. The rivers, harnessed to supply power, are the St. Lawrence, Richelieu and St. Maurice. The drainage area of these rivers being the Great Lakes for the St. Lawrence, Lake Champlain, gathering water from the Green and Adirondack Mountains, supplies the Richelieu, while the St. Maurice drains an area of approximately 18,000 square miles, consisting almost entirely of Forest lands to the North of the St. Lawrence.

In the earlier days several companies supplied power in different forms in the city and suburbs. These companies were finally amalgamated into two groups controlled by the Montreal Light, Heat and Power Co., and those operated by the Lachine Rapids Hydraulic and Land Company. In the earlier part of 1903 these two companies' interests were consolidated.

The Montreal Light, Heat and Power Company now controls the entire supply of gas and electrical energy in the City and its suburbs. The Company was incorporated by the Quebec Legislature in March, 1901, for the purpose of consolidating all the gas and electric companies doing business in the City and suburbs, and is at the present time operating the following companies :—

The Montreal Gas Company.
The Royal Electric Company.
The Montreal and St. Lawrence Light and Power Co.
The Imperial Electric Light Company.
The Lachine Rapids Hydraulic and Land Company, Limited.
The Standard Light and Power Company.
The Citizens Light and Power Company, and
The Temple Electric Company.

Perhaps the most notable feature in the operation of the system of the Montreal Light, Heat and Power



Load Curve.

Company, is the high load factors obtained. The minimum load factor over 24 hours per day during the summer months is 74% and during the winter months 76% to 77%, giving an average of about 75% for the whole year. The total output for the year 1903, being in the neighbourhood of 85,000,000 K. W. hours.

These exceptionally good results have been obtained through the policy adopted by the Company. During the winter months the maximum lighting and power load is not coincident. This is brought about by the Company making a very attractive rate for power which is not used between the hours of 4 p.m. and 7 p.m. of each day during the above months.

Electric light and power is distributed by the Montreal Light, Heat and Power Company in the City and Island of Montreal for a distance of about 16 miles along the river front, and to an average width of four miles back from its bank, and included in the service area is a strip of territory about one mile wide and four miles long on the main land opposite the City. Within the service area there are at the present time 10,600 customers using commercial arc and incandescent lamps, and 880 customers using motors, besides the towns in the suburbs supplied with street lamps.

The Company owns and operates two out of the three generating stations supplying power to the City, the one at Chambly and the other at Lachine.

The Chambly Power House, which obtains its power from the Chambly Rapids on the Richelieu River, is 308 feet long by 50 feet wide. The hydraulic equipment of this plant is designed for the development of 23,500 electrical H. P. There are eight (8) main units, each consisting of four 51" McCormick Turbines, mounted on a horizontal shaft for direct connecting to the A. C. generators. The wheels are mounted in pairs and are set in 15 foot penstocks over draught tubes 10 feet in diameter, 15 feet above tail-water, and are operated under a working head of 33 feet. There are two smaller units, each consisting of two 27" McCormick turbines, set in eight

Exterior View Chambly Power House.

foot penstocks, the same distance above tail-water as the larger units. These are used to drive the exciters for the A. C. generators. The wheels are all regulated by Lombard governors.

Direct connected to each of the large water wheel units is a 2,200 K.W. 152 rpm 2,200 V. 66 cycle two-phase generator. Four of the generators are of the well-known revolving field type made by the General Electric Company, and four of the Stanley induction type. The two exciters are each of 300 K.W. capacity at 125 V. and run at a speed of 250 rpm.

From each of the eight 2,200 K.W. two-phase generators, single conductor 750,000 c.m. paper insulated lead covered cables carry the current to the oil switches which are manually operated and which can be connected to either of two sets of busbars.

To the generator busbars are connected through G.E. type "H" motor-operated oilswitches, five banks of Westinghouse air-blast step-up transformers, each bank

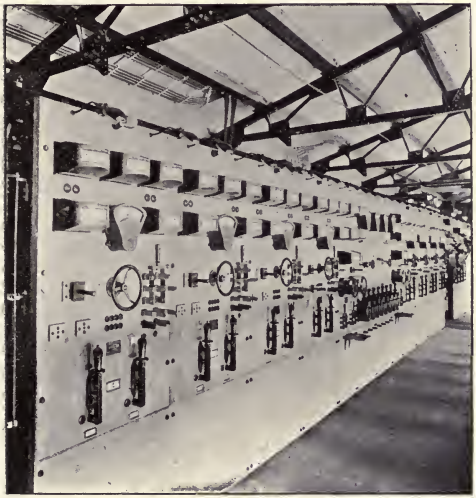
having a capacity of 5,500 K.W. By means of these step-up transformers, which are connected in "T" on the primary side, the voltage is transformed from 2,200 volts two-phase, to 25,000 volts three-phase. The high tension current is then taken to a selector knife switchboard and from thence by means of three conductor 25,000 volt paper insulated cables to the overhead lines, the cables joining same in a terminal house.

The terminal house itself is a one-story structure of steel, and cinder concrete, and is separated from the main

Generator Room Chambly Power House.

power house by the end wall. In plan, the terminal house is about 18 x 29 feet and rests on a steel frame work, the floor being about 20 feet above the foundation. The steel "I" beams on which the terminal house rests, extend out about 12 feet beyond the back wall, in order to support the timber frame work on which the transmission wires are supported.

Through the walls of the terminal house, hard wood bushing 4" x 4" x 12" boiled in parafine are set at an



Generator Switchboard Chambly Power House.

angle of 30 degrees. Ease of these bushings carries a glass tube of about 2¼ inches diameter through which the bare transmission wire passes.

The transmission lines are dead-ended inside the Ter-

minal House and the three conductor high tension cable joints same at this point.

After leaving the terminal house, the twelve bare conductors that make up the four three-phase circuits are carried on two separate pole lines, two circuits to a pole line. A short distance from the Chambly Power House the two pole lines cross the Richelieu River. In this crossing, six spans are employed and six concrete piers erected in the river to support the poles, two poles being set in each pier. Each pole crossing the river is double cross-armed. The length of each span is about 125 feet.

A little further on from the river crossing, the Chambly Canal has to be negotiated. It is accomplished by means of four steel towers,—two towers being used for each pole line. The length of span over this Canal is about 132 feet. The distance between the bottom of the lowest transmission wire and the surface of the water in the Canal is 148 feet. The top of each tower measures 16½ inches by 16½ inches, exclusive of the cross pieces which support the cross-arms.

Each tower is provided with a ladder and supports three sets of cross-arms, each consisting of four cross-arms in one horizontal plane. One set of cross-arms rests on the top of the tower ; the centre of the middle set is 36" below that of the highest and the centre of the lowest set is 30" below that of the second.

The wooden cross-arms on the towers are 13 feet long and the width across the four arms, making up a set, is about four feet. After leaving the towers at the Chambly Canal, the transmission lines are carried on cedar poles between 40 and 45 feet long, set 5 feet in the ground and 90 feet apart. The pole line runs over the right-of-way of the Central Vermont Ry., one pole line on each side of the track. At the Montreal end of the transmission line, the wires have to cross over the St. Lawrence river. The crossing is effected by carrying the wires over the top of the Victoria Bridge on special fixtures. Few people of the thousands, who are annually transported over the Victoria Bridge, realize that thousands of electrical horse

power are transmitted over their heads. From the Victoria Bridge, the transmission lines run to a point about 4,000 feet from the sub-station, where another terminal house is erected, similar to the one at the Chambly end. The reason that the last 4,000 feet of the transmission line is of underground is due to the fact that the Lachine Canal has to be crossed.

The transmission wire is of bare, medium drawn copper No. 00 B. & S. guage. Each circuit is arranged in the form of an equilateral triangle—30 inches centre. The cross-arms are Georgia Pine—11 feet long x 4" thick and 5" wide, and were treated with a preservative. The pins which are used are hickory, boiled in stearine. The insulators used on the Chambly transmission lines are 6" porcelain Bock and Mershon type triple petticoat.

The H. T. cable contains three standard copper conductors of 211,600 c.m. cross section each. Paper, satur-

Exterior View, Lachine Power House.

ated with compound is the only insulation in these cables. Outside of the paper is a lead sheath about 3-32 inches

thick. The side of each conductor is about 7-16 inches distant from the lead sheath at the nearest point and the distance between the conductors themselves is 11-16 inches. The lead sheath of the cables contains about 3% of tin. The outside diameter of the cable is about 3 1-16 inches.

The cable was manufactured and installed by the National Conduit & Cable Co., New York, N. Y.

The lightning protection for the Chambly transmission lines consists of barb wire. Three lines of barb wire are run on pony glass insulators on each pole line, two lines being run on the ends of the top cross-arms, 32" from the line wire, and the third on the top of the pole, the three barbed wires being joined together at each pole and grounded. In addition to this protection, Westinghouse low equivalent A. C. lightning arresters and choke coils are used,—these banks of arresters being located at each end of the transmission lines in the terminal houses.

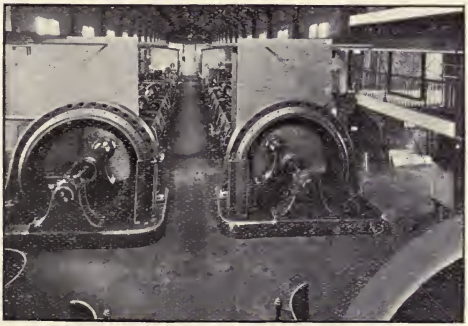
Lachine Rapids, on the St. Lawrence River, between he Island of Montreal and the South bank of the River,

Wheel House, Lachine Power House.

is the site of the second named power station. At this station the working head of water on the wheels is between 16 and 17 feet and is obtained from an unusual con-

struction. The St. Lawrence River, at the point where the power house is located, passes through a series of Rapids. In order to render a portion of the water available for power purposes,—a large breakwater was constructed a mile and one quarter in length, running parallel to the shore and at a distance of 1,000 feet from same. At a point about two-thirds of the way down from the upstream end of the breakwater, the Power House, (1,000 feet long x 50 feet wide) is built between the shore and the breakwater, and at right angles to same. The present hydraulic equipment of this station is for 8,000 electrical H. P. and consists of eight units, each unit being made up of 6 vertical turbines of 51 inches diameter, connected to a jack shaft by means of crown gears and pinions.

All are governed by Lombard Governors. To each water wheel unit, consisting of six wheels, is connected a 750 K.W. 60 cycle three phase 5,000 volt revolving field generator, the normal speed of which is 180 rpm. On account of the great length of the Power House, there are three generator rooms, two of which are occupied at the present time, there being four generators in each room.



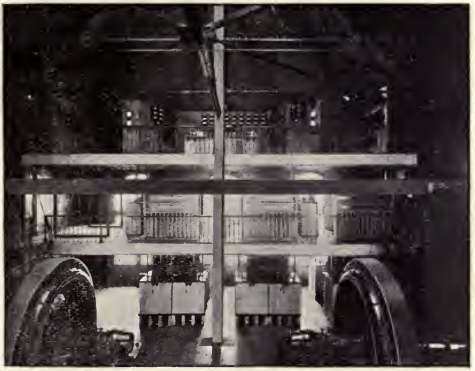
Dynamo Room, Lachine Power House.

To supply the necessary exciting current for the A. C. generators, there are four exciters each rated at 75 K. W. at 120 volts. The exciters are driven at a normal speed of 660 rpm. by a belt from a separate water wheel. On account of the wide range of exciter voltage necessary, the exciters can operate satisfactorily at any voltage between 90 and 175 volts. This wide range is necessary owing to the fact that the available head at this power house is subject during the winter season to much variation, causing changes in speeds of both the alternators and exciters, and these changes are compensated for by different currents and degrees of saturation of the fields of the A. C. generators, in order to maintain a constant A. C. voltage. With a view to these changes of saturation, the fields of the A. C. generators were so designed that at full speed and voltage, their degree of saturation is below the normal figure.

The current is taken from the A. C. generators by means of three-conductor paper insulated cable through three-pole solenoid-operated oil-switches to busbars. From the busbars, current is transmitted by means of cables carried in a fireproof subway to poles outside of the Power House, where they join ten aerial three-wire three-phase transmission lines. The wires of the transmission lines are bare copper of No. 0 B. & S. gauge and are arranged in the form of an equilateral triangle, 18 inches between wires. Six of the transmission circuits are carried on steel poles, the other four transmission circuits on cedar poles to the sub-station in the city, a distance of about five miles.

In order to protect the transmission lines from lightning, arresters are installed at different points along the transmission line. Each transmission line is connected to the busbars in the generating station, through three-pole solenoid-operated oil switches, to each of which is attached an overload relay. At the receiving end of the line, the transmission circuits are brought into the sub-station by underground cables, the last 2,000 feet of each circuit being cable. The transmission circuits are con-

nected in the sub-station to busbars through expulsion fuses and knife switches.



Switchboard Galleries, Lachine Power House.

On account of the great length of the Lachine Power House, considerable difficulty was experienced in operating the plant so as to give good service. In order to overcome as much as possible the disadvantages, the bench board type of switchboard was adopted, and the present switchboard equipment has given very satisfactory results. There are many novel features used in the operation of the board, principal amongst which is a complete signal system between the wheel attendant and the switchboard operator. Also the switchboard operator, by means of a little key on the bench board, can stop and start any generator in the Power Houses—he having complete control over the governors of the water wheels.

There are at the present time five sub-stations distributing power to the city and suburbs. The principal ones (Central Station, McCord Street sub-station and the Shawinigan sub-station) are tied together by means of

2,400 volt tie lines. At these three sub-stations, the energy received from the generating stations is transformed and converted to alternating current at 2,400 volts, 60 or 63 cycles, two or three phase.

Exterior View, Central Station.

The Central Sub-station, which is a large and handsome building, is the largest and nearest of the three to the business centre of the city. The four high tension cables of the Chambly transmission lines are brought to a selector knife switchboard similar to the one at the generating end of the line. To the selector board is connected ten 2,750 K. W. transformers, grouped in banks of two. These transformers are of the air blast type, and were made by the Westinghouse Electric and Manufacturing Co., and reduce the current from 22,000 volts, three pahes, to 2,400 volts, two phase.

There are also installed in this station 26 transformers of the natural air cooled type of 60 K. W. capacity each, for operating the enclosed A. C. city arc lamps. The transformers taking the energy from the main transformers at 2,400 volts, and stepping up to 4,800 volts.

The A. C. arc light equipment of transformer and regulators was made by the Western Electric Co. About half of the D. C. load is distributed from this station. Synchronous motors connected to 250 volts. D. C. generators furnish current for the three-wire 250 volts, D. C. system.

Rear View, H. T. Switchboard, Central Station.

Ranged about three sides of the sub-station on a gallery and on the side, are the high and low tension switchboards which control and distribute the energy. All the switches on the distribution boards are automatic, controlled by time limit devices. This station distributes power to several of the largest customers.

The McCord Street station receives current at 4,000 volts, three phase, 60 cycles, from the Lachine generating station, and transformes same for distribution at 2,400 volts, three phase. The transformer equipment of this

station consists of nine 250 K. W. air-blast transformers, built by the Wagner Electric Co., and four 1,000 K. W. air-blast transformers built by the General Electric Co.

The Shawinigan substation is situated in Maisonneuve, a suburb of Montreal. At this substation, the Montreal Light, Heat and Power Co. receives power at 2,400 volts two and three phase from the Shawinigan Water & Power Co. who own and operate the power plant at Shawinigan Falls.

In the centre of the City, there is a small substation receiving current from Lachine Power House, and by means of rotary converters transforming the current to D.C. 250 volts for the remainder of the D.C. power system.

Besides the water power plants the company has several steam plants, located at different points throughout the City. These plants, which are used as reserve, have a total capacity of between 7,000 and 8,000 electrical H. P.

The Company's Engineering staff is at the present time busily engaged laying out a system for consolidating the different systems and also constructing 11,000 volt three-phase tie-lines between the principal substations.

The system considered the best for commercial purposes is three-phase, and also on account of the two power houses owned and operated by the Company, operating at different frequencies, it has been considered advisable to strike a mean between 60 and 66 cycles, and adopt 63 cycles.

Electrical Equipment of The Canadian Pacific Railway Co.

THE electrical equipment of the Canadian Pacific Railway dates from a comparatively few years back and is at best only but the beginning of what can and will be done to utitize the advantages of electrical transmission in connection with its work. In that part of its line lying in the Rocky Mountains and the Selkirks, there is a great abundance of water power which will, without doubt, in the near future, be far more fully utilized that at present. The high price of fuel offers special inducements for hydraulic undertakings, and the advance in electrical traction for steam railroads will, without question, lead to a substitution of electrical locomotives for steam engines within a comparatively few years. While this subject is being investigated, nothing definite has been decided so that no description of existing apparatus can be given.

While a number of smaller plants for the utilizing of the water power in the Rockies for mechanical purposes of the Company at different stations have been installed, they are none of them of very large size, and do not offer any points of special interest. There are a number of large hydro-electrical plants adjacent to the Canadian Pacific, but none of them are owned by the Company and their description will doubtless be given by engineers more directly interested.

Apart from such smaller uses of electricity the Canadian Pacific has under construction two large shop plants for the construction and repair of its railway stock, in which all the power will be distributed electrically. These shops are the "Angus Shops" in the City of Montreal, and the New Shops at Winnipeg, Manitoba. The first of these plants was begun in September, 1902, and it is expected will be in full operation before the end of the

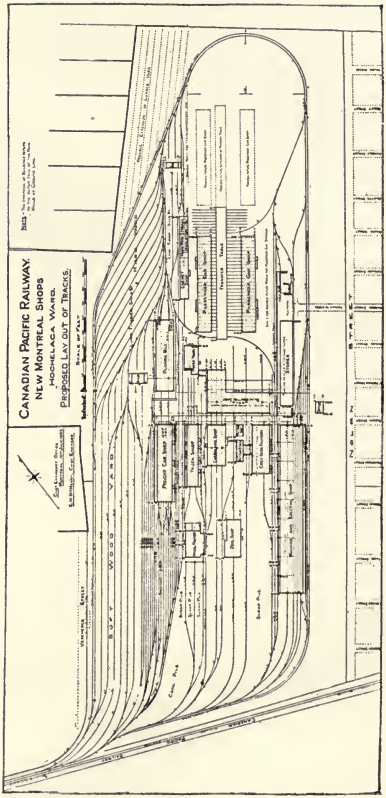
present year. The Angus Shops are of a special interest as their "raison d'être", or at the least the reason for their magnitude, lies in specifically Canadian conditions. While railway corporations in the United States and other countries of older development are able to purchase to advantage a large part of their equipment from manufacturing concerns, the comparatively narrow market in Canada has limited the establishment of locomotive and car shops in private hands. It has therefore been determined in order to avoid the payment of duties and to utilize home labor to the largest posssible degree to build as far as possible all locomotives and cars, both passenger and freight, which the Company may require.

The City of Montreal presents special advantages for manufacturing. It is at the head of navigation for marine vessels, reducing the cost of raw materials. It has coal at comparatively low rates, while the supply of labor is at lower wages than those that prevail in the West. The Angus shops are situated on the Quebec Line of the

C P.R. Angus Shops.—Machine and Erecting Shop

Canadian Pacific Railway, in the Eastern portion of Montreal. The site has an area of over two hundred acres, and there are over twenty buildings in all, covering a total area of 832,000 square feet, or about twenty acres. Of these buildings, the largest, 162 ft. by 1166 ft., will be

used as a machine and erecting shop for locomotives. It is intended to repair here from four to five hundred engines per year, and in addition to construct from 75 to 100 new ones. All boiler and tender work will also be done in this building, the eastern end of which is equipped with a riveting tower and hydraulic machinery for boiler and tank work. The Grey Iron Foundry of 75 tons daily capacity and the large Blacksmith shop are adjacent to the locomotive machine shop and feed into it. The Car Department has a large storage for lumber at the north end of the shops and besides drying kilns there is a sawmill 126 ft. by 500 ft., a cabinet shop 60 ft. by 280 ft., and two passenger car shops 100 ft. by 672 ft., a freight car shop 107 ft. by 540 ft., a truck shop 82 ft. by 434 ft., a car machine shop 130 ft. by 288 ft. Besides this, a complete wheel foundry with a capacity of turning out three hundred chilled car wheels per day, and a shop 120 ft. by 260 ft. for making the frogs and switches to be used on the whole line of the road. These shops are constructed in a plain but substantial manner. They have abundance of light from very large windows and ample area of skylights, the latter covering about 25 per cent. of the roof. In the construction of the buildings great attention was paid to making them as fire-resisting as possible without incurring excessive expense. The roof construction follows the rules of mill construction closely, the planks being three inches thick everywhere, resting on heavy beams eight to ten feet apart, these latter being in turn supported on steel trusses or heavy timber trusses or rafters. All walls are of brick and fire walls and curtains are put in everywhere where they do not interfere with the uses to which the buildings are to be put. For the extinguishing of fires all buildings are equipped with a wet system of sprinkler heads, besides numerous stand pipes equipped with hose. Besides this about five miles of eight, ten and twelve inch fire mains were laid completely encircling the buildings, with three way hydrants, placed about 200 ft. apart, supplied with ample fire hose. In addition to the fire system a mill water supply system,


CANADIAN PACIFIC RAILWAY
NEW MONTREAL SHOPS
HOCHELAGA WARD.
PROPOSED LAY OUT OF TRACKS.
SCALE 8 FEET
Car Repairers Shop
Blacksmiths Shop
Machine Shop
Erecting Shop
Boiler Shop
Power House
Foundry
Pattern Shop
Paint Shop
Store House
Engine House
Turning Table
Water Tank
Coal Pile
Boiler Pits
Wood Yard
Engine Shop
Passenger Car Repair Shop
Passenger Car Paint Shop
Passenger Car Shop
Passenger Car Yard
Freight Car Repair Shop
Freight Car Paint Shop
Freight Car Shop
Freight Car Yard
Locomotive Repair Shop
Locomotive Paint Shop
Locomotive Shop
Locomotive Yard
Wood Working Shop
Saw Mill
Lumber Yard
Coal Yard
Coal Pile
Boiler Pits
Engine Shop

which does not touch the fire mains, is provided. An ample system of sewers is also provided connecting all buildings, as well as for surface drainage.

Water System.—A pit in the pump room contains all the pumps for the fire and general supply service of the plant. There are two Northey's underwriter pumps each with a capacity of 1,500 gallons per minute at 100 pounds pressure, and one Northey pump with a capacity of 25,000 gallons an hour, having their suction pipes connected to a pair of 6-inch artesian wells 550 feet deep and to the high and low pressure city water mains. They discharge normally to the circular concrete storage reservoir for shop service. There is room in the pit for an additional pump with a capacity of 25,000 gallons per hour. All pumps are cross-connected and by-passed so as to be interchangeable in their service and to draw from the reservoir, the wells or the city supply. They deliver to the reservoir, the fire service, the distribution mains or to a 75,000-gallon steel tank on top of a 70-foot tower, which is connected to the mill supply.

Heating System.—A thorough comparative study was made of the different systems of the shop heating by direct steam and hot water and by blowing methods, the latter being finally adopted as most efficient and economical where the requirements are so severe on account of the large spaces to be warmed, the high proportion of window area and the low external temperature. The apparatus was built and installed by the B. F. Sturtevant Company, of Boston. Steam is distributed in tunnels to the different buildings from the central power-house which is about 2,600 feet from the most distant part of the system. The buildings have a combined volume of about 26,000,000 cubic feet, and from ¼ to ½ of the wall surface is glazed, besides which there are skylights aggregating 25 per cent. of the roof surface. The specifications require most of the buildings to be heated to a constant temperature of 65 degrees when the temperature outside is 10 degrees below zero. The radiation for this service contains an aggregate of about 200,000 linear feet of

1-inch pipe, in vertical coils with cast-iron bases, which are coupled up in sections of about 200 feet each. The fans are calculated to have a capacity sufficient to completely change the air in any building in about 20 minutes. In all the buildings they will, however, be used in very cold weather to maintain a closed circulation and return the air in the building to the heaters without receiving any cold air from outside.

In the planing mill the fan engine and heaters are located on platforms between the roof trusses. In most of the other buildings they are located in one or more separate lean-to brick annexes. Each set of heaters is supplied with both exhaust and live steam mains. In the locomotive and blacksmith shops the hot air from the heaters is distributed partly underground through brick conduits; but in the other buildings and in parts of these, the distribution system consists of cylindrical overhead galvanized iron ducts, supported on the lower chords of the roof trusses, having outlets through vertical pipes carried down beside each of the interior columns.

All machine tools, the cranes, the car transfer table to the passenger car shops, the fan motors for the exhaust fan and pressure fans in the blacksmith shop, the blowers in the foundries, and in fact all apparatus except the fans of the Sturtevant Company heater and a small amount of hydraulic apparatus in the boiler shop, are electrically driven. The problem of the proper form of electrical installment was the subject of extended study on the part of the Chief Engineer and his assistants, as well as special experts engaged for the purpose. The distances between the different shops are considerable, but there is no long distance transmission of power to other points to be considered. For this reason the use of both direct current and alternating current was proposed, and plans and specifications were drawn up for operating all parts of the shops entirely by direct current motors as well as by an alternating current system. The difference in cost was very small. As finally planned, the power is

distributed from the central Power House to all parts of the grounds by 600 volt three phase A. C. current, 60 cycles (7,200 alternations), but certain important machine tools in the locomotive shop and the frog shop, as well as all travelling cranes and some small motors in the foundries, are operated by a 250 volt continuous current. The use of motor generators was considered for the production of this comparatively small amount of direct current. It was finally decided to put in a special engine and generator in the Power House. The power plant is in a building located as centrally as possible with the provision that it should be close to the planing mill. The latter requirement is added as the large amount of sawdust and shavings produced in that building is carried directly to the Power House for consumption in the boilers. A complete exhaust fan system of shavings collection has been put in the planing mill and the cabinet shop, and additional fans are located on the roof of the Power House with cyclone for the collection of shavings from the planing mill and cabinet shop. A large brick vault for surplus shavings is provided close to the Power House. It is estimated that when the freight car shop and mill are operated at their full capacity, namely thirty box cars per day, the shavings produced will be equivalent in heating power to about eighteen tons of Nova Scotia soft coal per day. The Power House is a brick building about forty feet in height, 100 ft. by 160 ft., divided by a longitudinal centre wall equally between the boiler room and the engine room.

Power Plant.—In the boiler room are four 416-horse-power Babcock & Wilcox boilers for a working pressure of 150 pounds and superheat of 150° F. and one 300-horse-power boiler of the same make for a pressure of 300 pounds to be used in testing locomotives. These boilers are equipped with Neemes's shaking grates and are stoked by hand. The induced draught system is operated by two 10-foot Sturtevant fans which make about 200 revolutions per minute and are connected with a steel stack 8 feet in diameter and 70 feet high. Two

Green economizers of sufficient rated capacity to serve the five boilers have been installed, and provision is made for the future installation of three more boilers of 16 horse-power each. All the boilers are connected to a 14-inch header, and reducing valves and a by-pass are provided to permit the steam at 300 pounds pressure to be used with the low-pressure battery when the high pressure is not required for testing purposes. Two 12x7x12 inch Northey feed-water pumps built by the Canada Foundry Company, Toronto, have been put in for the 416-horse-power boilers and two 6x3½x6 inch Worthington feed-water pumps for the 300 horse-power-high pressure boiler. There is also a feed-water heater, made by the Goubert Manufacturing Company, New York, of sufficient capacity for all the boilers.

The ashes are discharged to floor hoppers, from which they are emptied at convenience into cars in a tunnel running beneath the boiler house and terminating at an air hoist for lifting the dump cars to the surface tracks, on which they are run to the spoil banks.

In the engine room there are three 750-horse-power and one 375-horse-power cross-compound horizontal Corliss engines, making 150 revolutions per minute, built by the Robb Engineering Company, Amherst, Nova Scotia, direct-connected to three 500-kilowatt and one 250-kilowatt three-phase 600-volt alternating-current generators. Besides these generators there are two 250-kilowatt 250-volt direct-current dynamos for the crane service. The alternating-current generators, motors for some of the tools and the exciters were built by the Canadian General Electric Company. Air is compressed by machines brought from the old shops and is delivered at 100 pounds pressure through a 7-inch and a 2-inch main leading to the different parts of the plant and connected to one or more receivers in each of the buildings. The engine house is served by a 10-ton travelling crane operated by hand power.

A tunnel from the power house was run to most of the important buildings, and carries on wall brackets the live

steam pipe for heating at night, an exhaust steam pipe for heating by day, a high-pressure steam pipe for locomotive tests, air pipes for pneumatic service and a return pipe for the drainage of all the heating apparatus, the condensation water from which is saved and used again. All steam and exhaust pipes are jacketed with asbestos air-cell covering wired on.

Another View of the Angus Shop from North.

Electric Installation.—The shops are designed and equipped for work which does not vary greatly in character. Hence the different tools are to be used for a uniform service so that they can, in most cases, be economically operated by constant-speed electric motors, avoiding the complication of variable-speed motors except for a very few machines. The work in the machine shop has been divided into general classes, namely: wheel-finishing; finishing moving parts, such as links, pistons, valves, etc.; heavy turning, boring and planing. Brass-finishing and other light work is done in the gallery and the machining of heavy parts is done in one of the side aisles. In a total of about 200 electric motors only about 15 are of variable speed. The system adopted uses three-phase 600-volt current without transformers and gives 550 volts at the motors. All except the direct-current motors are 10 to 50-horse-power, induction type,

three-phase, 550-volt machines made by the Canadian General Electric Company, of Peterborough, Canada.

A three-phase switchboard with four generator distributing and exciter panels of the General Electric type has been installed. Outside wiring is done with overhead construction bare-copper main feeders on structural steel poles. In the buildings there is a mixed system of open porcelain cleats and slow-burning weatherproof wire on the ceilings, and Richmond conduits and rubber-covered wires on the side walls. Panel boxes are supplied, however, for about every 10 kilowatts of lighting and for every 100 horse-power of motor wire. For shop and yard illumination there are 400-110 volt enclosed arc lamps of the Canadian General Electric make, supplemented by 3,800 16-candle-power incandescent 110 volt lamps. In the passenger car shops the lights are spaced equi-distantly and low tension arc-lamps are installed on account of their economy and better results for general illumination. In the yards there are 50 enclosed series arc lamps.

The shops are equipped with a complete local telephone system for a 75-drop switchboard and 60 telephones, besides certain phones with long distance connection. The system is equipped with metallic circuit, motor generators for ringing and self-restoring drops. The electric department of the Canadian Pacific Railroad Company is installing all the electrical wiring. The general office at the plant is wired throughout with conduit concealed work, and in every room there is a belt line of wire running around the walls, near the ceiling, behind an oak moulding which can be removed and a light connected at any point without disturbing the line.

In the shops the small machine tools are arranged in groups, which, in most instances, are operated by a motor seated on an overhead platform between the roof trusses. In order to determine the load factor for the groups of tools and for the plant, a series of practical tests was made on a large number of iron and woodworking machines used in similar shops operated by steam power. A small

Car Machine Shop.

generator and balancer was driven from a countershaft near the centre of the shop and operated a small portable motor and controller. The latter was taken to any required machine and belted directly to it or to its countershaft, and the machine worked to its limit under different conditions, thus determining its capacity and maximum horse-power. About 45 per cent. of the aggregate maximum horse-power was used as a basis for proportioning the sizes of the conductor mains.

WINNIPEG SHOPS.

The Winnipeg Shops are in almost every respect similar to the shops just being completed at Montreal. They are about one-third as large and are to be devoted exclusively to repair work. The locomotive shop is to be 160'x800' with a central transfer table over two-thirds of its length, this table being entirely covered on account of the severe climate. The power house will be equipped with apparatus similar to that in the Montreal shops as given above, excepting only that the alternating current will be used throughout for lighting, as well as for all power purposes, including the cranes and transfer table. There will be

two generators of about 600 K. W. capacity, direct connected to two 900 H. P. Rice & Sargent engines. The boilers will be five 250 H. P. Babcock & Wilcox boilers, 125 lbs. pressure, 100 degrees super-heat. In other respects the arrangement of the power plant follows the lines of that of the Montreal shops very closely. The same may be said with regard to water and compressed air supply, and other features.

FORT WILLIAM POWER PLANT.

The Canadian Pacific Railway has completed within the past year a power plant at Fort William by which it is intended to operate all of the large grain elevators of the Company at that point as well as to do all the lighting of the coal docks and to operate the machine shop of the Company. The local power houses which were in use previously in connection with each elevator have been abandoned. The power plant is also very similar to that at Angus Shops. There are four boilers identical with those at Angus and two 500 K. W. generators directly connected to 750 H. P. engines, this unit being identical with the Angus units excepting only that the engines are condensing engines.

In the different elevators induction motors are used for driving two or three of the elevator legs arranged in groups from each motor. The installation of these motors has been a complicated and difficult problem, but the saving in cost of operation of these buildings will amply justify the expense involved.

Electric Power and Lighting Equipment of the Canadian Canals.

THE Canadian Canals, viz., the Lachine, Soulanges, Cornwall and Welland Canals, are part of the great waterway which connects the great Lakes of the Canadian West with the Gulf of St. Lawrence.

The St. Lawrence River, the Canals and the Great Lakes form together the great artery of commerce for the Dominion of Canada, serving to carry the freight of the West to Europe, besides supplying the local traffic of the cities, towns and villages lying along their shores.

This inland water route, unsurpassed in the world for its commercial usefulness, has a total length of 2,400 miles, 1,000 miles from the Atlantic Ocean to Montreal the metropolis of Canada, and 1,400 miles to Lake Superior. It allows free and safe navigation to large vessels up to 14 feet draught.

The extensive series of rapids on the St. Lawrence River between the Lakes and Montreal have necessitated a chain of canals to be built to provide for uninterrupted navigation.

The aggregate length of these canals is 70 miles with a total lockage of 536 feet through 54 locks.

In the year 1903, 7,365 vessels of all descriptions passed through the locks of the Lachine Canal, carrying over two million tons of freight and 35,000 passengers.

To accommodate this large and continuously increasing traffic the Government decided some years ago to light the canals and operate the locks and bridges by electric power.

The lighting makes navigation as easy at night as in day light and lockages are performed as rapidly and as easily as they could be in the day time. The electric mechanism also permits of much more rapid lockage than

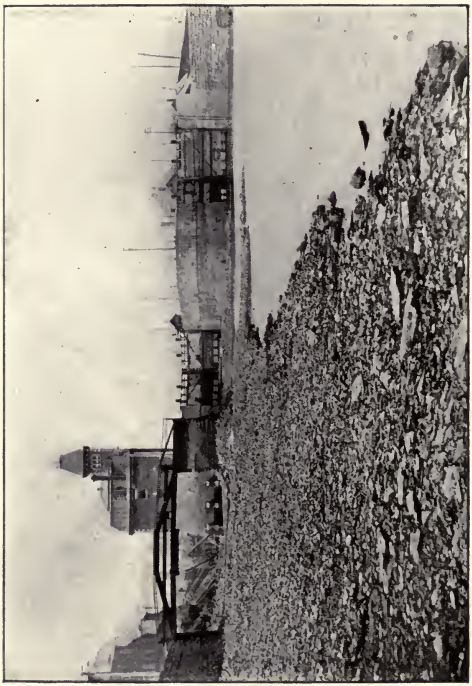


Fig. 1—Power House—Lachine Canal.

could be carried out by hand, when, the lockmen laboriously turned the cranks of the winches, and it also reduces the force of lockmen to one half the crew formerly required.

The Lachine Canal—Immediately above Montreal are found the Rapids of Sault St. Louis or Lachine Rapids; these are the first obstruction to westward navigation in the St. Lawrence River. The length of the Lachine Canal is 8¾ miles with four locks. The total difference of level is forty-five feet. Six heavy swing bridges span the Canal.

Electric Power—Advantage is taken of the available water power at Cote St. Paul Locks, about half way along the Canal, to generate electric current for lighting the Canal, the locks and approaches of the bridges, also to operate the lock gates, waste weirs and bridges.

The Power House is a neat building of pressed bricks above a line of cut stones and concrete arches.

The working head of water is about nine feet. The electric generators installed are 75 K. W. revolving field 2,400 volt, 60 cycle, 3 phase generators operating at 600 R. P. M. They are belt driven to 125 H. P. turbines. An exciter is provided belted to a separate water wheel. The switchboard consists of two generator panels, one feeder panel, one exciter panel and one arc lamp circuit panel. The power house is electrically heated.

The pole lines for the lighting and power circuits are of substantial structure, 35 foot cedar poles are used placed 100 feet apart. Ornamental braces and lamp brackets gives these lines a neat and artistic appearance.

One hundred enclosed A. C. arc lamps are distributed along the canal spaced every 400 feet, and eight lamps are used at each lock thus giving a decidedly brilliant illumination.

Lock and Sluice Gate Mechanism—The lock and sluice gate mechanisms differ materially on the different canals, on account of the differences that exists in the type of gates in use and also on account of different local conditions necessitating different designs of machinery.

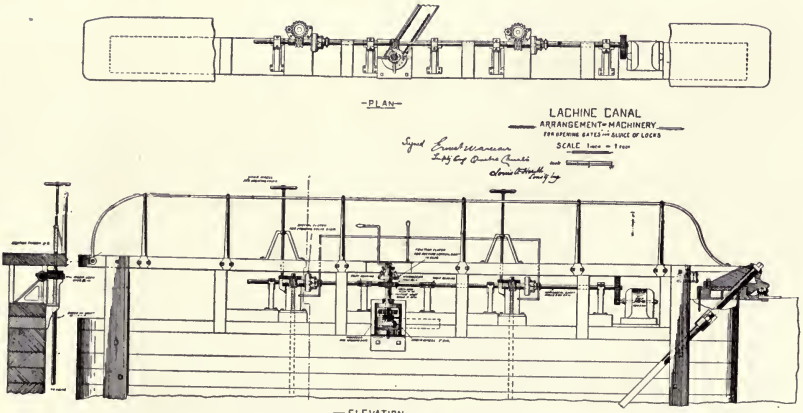


Fig. 2.—Lock and Sluice Gate Mechanism—Lachine Canal.

On the Lachine Canal it was deemed necessary to free the coping of the Locks entirely from machinery. A large amount of traffic and handling of freight is done at the Locks and exposed machinery would likely have been injured. The whole of the driving machinery for operating one gate and its sluices is placed on the gate under the platform.

Power is supplied by a 5 H. P. 3 phase 220 volt induction motor running at 1,120 R. P. M. This motor is geared to a horizontal shaft running approximately two-thirds

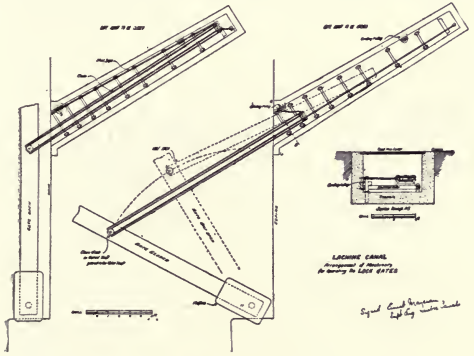


Fig. 3.—Tracing Mechanism for Operating Gate.

the way along the gate. Three worm gears are placed on this shaft, the right hand and left hand gears operate the sluice valves through friction clutches. The centre gear operates the gate; it engages a horizontal worm wheel placed on a vertical shaft, which is the pivot for a channel beam resting on the gate on one side and working in a cut provided in the coping at its outer end. A chain wheel keyed to the vertical shaft through a friction coupling imparts its motion to an endless chain running inside the channel beam.

The change from opening to closing the gate is obtained by reversing the motor.

In fig. 3 is shown three positions of the beam with gate opened, gate half closed and gate closed.

In starting up this apparatus, the motor is started practically without load, simply the friction of the horizontal shaft in its bearings and in the pinion and gear. The motor is allowed to reach full speed before the load is applied. This is done gradually by means of the friction clutches.

This system is working very satisfactorily.

THE CORNWALL CANAL.

The Power House supplying electric current for the Cornwall Canal is situated at Mille Roches. The water is

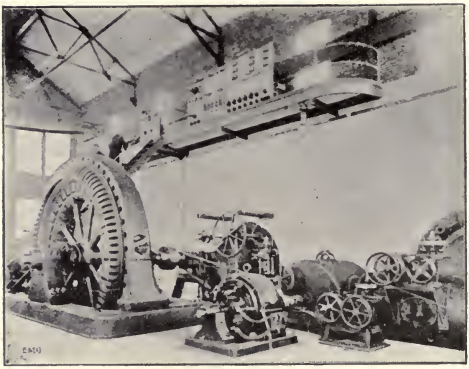


Fig. 4.—Power House—Cornwall Canal.

taken from the Canal through an artifical lake. The head of water is about thirty feet.

The power house is large and well equipped. One 1,000 K. W. 2,200 volt A. C. generator is installed with

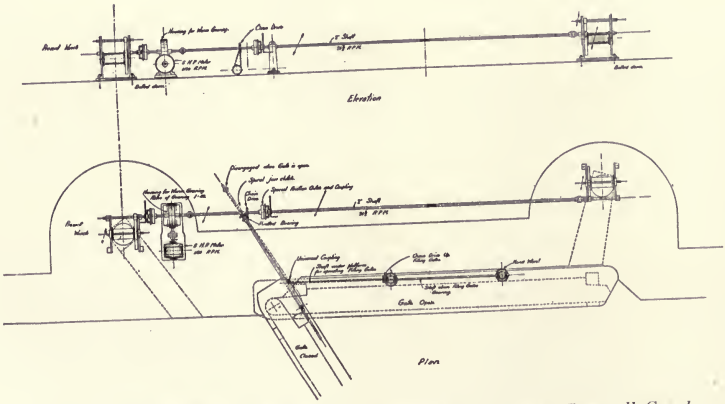


Fig. 5.—Arrangement of Machinery for Operating Lock Gate—Cornwall Canal.

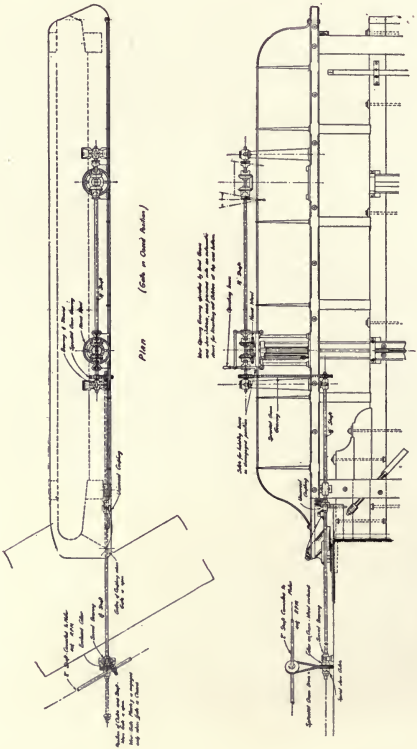


Fig. 6.—Arrangement of Machinery for Operating Weir Gates and Locks—Cornwall Canal.

the necessary exciters and switchboard. The 2,200 volt current is stepped up to 11,000 volt for the power circuits and 4,400 volts for the arc lamp circuits. The lighting of the Canal is carried out in a very liberal manner, an arc lamp being located on every fourth pole, the poles averaging about 100 feet apart. At the locks as many as twelve or fourteen lamps are located so as to brilliantly illuminate both ends of the locks as well as the intervening space.

Mechanism for Operating the Lock Gates—The equipment for operating the lock gates and weirs was adapted for use in connection with the winches and weir gate mechanisms used for hand operation. The motors are 5 H. P. 550 volt induction motors. One motor placed on each side of a lock and on the coping, operates through shafting and friction clutches, the two winding winches which control the chains for opening and closing the gates. The arrangement of motor bed, gearing and speed reduction will be clearly understood by referring to the drawings and figures.

To operate the sluice valves which are on the gates a short length of shaft which carries a chain wheel similar

Fig. 7.—Soulanges Canal at night.

to a sheave in a chain hoist is turned at an angle to the main working shaft and is connected to it by a welded link chain made endless. The mechanism for the sluice valves is clearly shown in Fig. 6.

The induction motors are protected by removeable galvanized iron hoods. This equipment has been in operation two seasons and is operating without any trouble. At the upper end of each lock is located a small switchboard cabin in which are placed the transformers connecting to the 11,000-volt mains to the motor circuits operating under 550 volts. A high tension fuse board is provided also a low tension switchboard with switches, fuses and auto starter connections for the operation of the motors.

THE SOULANGES CANAL.

The Soulanges Canal is without doubt the finest link in this chain of Canals. It is about 14 miles long, leaving the foot of Lake St. Francis just below the village of Coteau Landing and is led straight through the River

Fig. 8.—Power House, at Grease River—Soulanges Canal.

Ottawa about two miles from its junction with the St. Lawrence River at Cascade Point, Lake St. Louis. There is a total fall of 82 feet overcome by five locks, each 280 feet long by 46 feet wide.

The power house, which is a beautiful building of red brick, is situated nearly half way along the canal. The head of water is about 21 feet, the water being drawn from the canal and discharged in the St. Lawrence in a wide tail race. Fig. 8 shows the tail race view of the power house.

The electrical equipment consists of two 264 K. W. 60-cycle 2,400-volt, 3-phase revolving field type generators operating at 225 R.P.M. Their shafts are direct connected to Victor turbines. The two exciters are belted to the

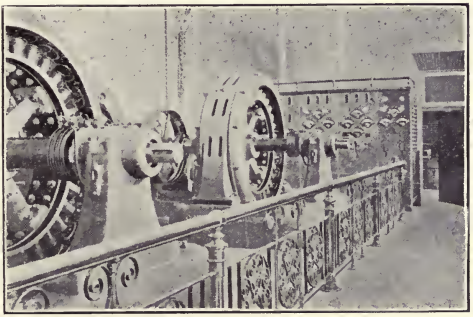


Fig. 9.—Interior of Power House—Soulanges Canal.

water wheel shafts. The switchboards consists of two generator panels, two feeder panels and one exciter panel, fitted with the usual instruments. Provision is made to run generators and exciters separately or in parallel.

The pole line construction is very artistic, presenting an exceptionally pleasing appearance. British Columbia cedar poles, sawed octagonal, painted white, are used

throughout; the cross arms which are of red pine are supported by an ornamental cross-arm brace.

The lighting consists of alternating multiple enclosed arc lamps placed 480 feet apart on one side of the canal. Each lamp is supplied with current from a 1,000 watt, 2,080-115 volt transformer. At the locks and the bridges the lamps are spaced closer and are on both sides of the canal.

Highway Bridges—The canal is spanned by seven bridges of 180 feet span and weighing about 100 tons each. The operating apparatus consists of a gear and friction mechanism driven by a 2 H. P., 220 volt, 3-phase

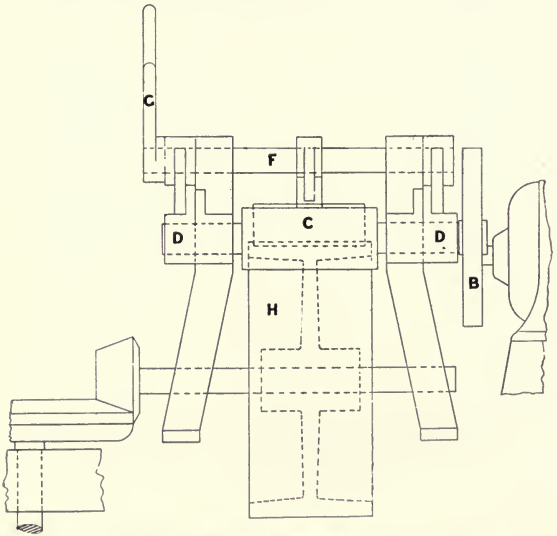


Fig. 10.—Mechanism for Opening and Closing Bridge—Soulanges Canal.

induction motor located in a cabin of very attractive appearance placed in the centre of the bridge. A pinion A on the motor shaft drives a gear B on a countershaft on which is keyed a paper friction pulley C. This counter-

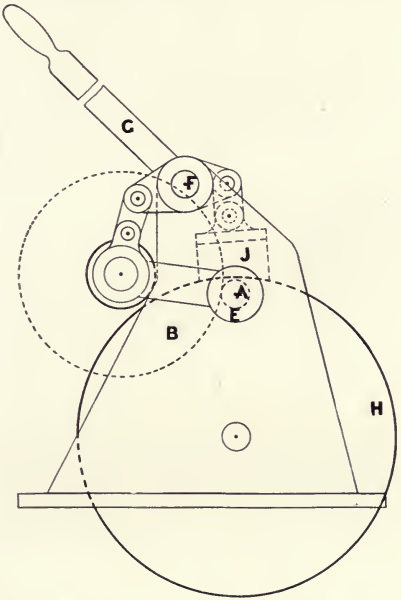


Fig. 11.—Mechanism for Opening and Closing Bridge—Soulanges Canal.

shaft turns in bearings D, which are located on the ends of two arms or links; the other ends E of these links are held by studs which are axially on a line with centre of motor shaft. The bearings in which the countershaft

turns are also connected by means of links to cams on another shaft F. on which is secured a lever G.

By moving the above mentioned lever in one direction the paper friction pulley is brought in contact with a cast iron pulley H, which is keyed to the main shaft which operates the bridge mechanism through a bevel pinion and gear.

Fig. 12.—A Lock—Soulanges Canal.

On the above mentioned lever shaft F is located another cam which is attached by means of a link to a brake shoe J ; this is brought into contact with the cast iron friction pulley by moving the lever in a direction opposite to that above referred to. By a simple movement of the lever in one direction the bridge can be started in motion or it can be stopped or retarded by a motion of the lever in the opposite direction.

Lock and Sluice Gate Mechanism—A 3 H. P. induction motor is geared to a friction mechanism involving the same principles as that described for operating the bridges. The gates are closed or opened by means of a strut or draw bar hinged to the gate under the gate platform at the end of which is a rack and pinion mechanism worked by the friction apparatus described. The whole machinery is placed in a water tight cast iron box which projects about 15 inches above the coping of the lock.

The system is extremely flexible and has shown to be working remarkably well having been in operation for two years. The lock gates are opened or closed in one minute.

THE WELLAND CANAL.

The Welland Canal is not yet equipped with electric power, the contract for the lighting, however, has been given and the equipping of the gates will be done shortly.

The Bell Telephone Company of Canada, Limited.

THE Bell Telephone Company of Canada whose head office is in Montreal, was incorporated in 1880 by special Act of Parliament with a capital of $500,000. In that year the company acquired the telephone plants of the Montreal Telegraph Company, the Dominion Telegraph Company, the Canadian District Telephone and Telegraph Company of Montreal, the Western Union Telegraph Company, the London Telephone Company, the Hamilton Telephone Company and the Windsor Telephone Exchange.

All the Telephone Patents at that time were owned by the Canadian Telephone Company, comprising those of Blake, Bell, Edison, Gray, Anders, Watson, Jacques and others, and the Bell Telephone Company of Canada was licensed to use these patents.

In 1882 the Bell Telephone Company acquired the stock of the Canadian Telephone Company, and thereby became the owner of all the telephone patents then existing in Canada.

In this year the first submarine telephone cable was laid, viz: between Windsor and Detroit; and the first Long Distance telephone lines were constructed in Canada, viz: between Toronto and Hamilton, and Windsor and Amherstburg.

The following figures show the growth of the Company's business:—

Year	Capital	Exchanges	Subscribers	Miles of L.D. Line
1880	$ 500,000.	32	2 000	
1885	1,200,000.	175	9,614	3,000
1890	1,494,000.	363	19,350	8,228
1895	3,168,000.	613	28,809	14,851
1900	5,000,000.	837	38,360	21,350
1904	6,000,000.	1093	57,172	30,969

The Company has erected and owns four Exchange Buildings in Montreal; three in Toronto District; two in Quebec, and one in Ottawa, Hamilton, London, Sherbrooke, Berlin, Winnipeg and Carman, Manitoba.

The following is an extract from a paper entitled "History of the Telephone in Canada," read before the Canadian Electrical Association by Mr. L. B. McFarlane, General Superintendent of the Company.

"The Telephone in Canada—the country that can with truth be called the birthplace of the Telephone.

"Professor Alexander Graham Bell's home was for several years, prior to the invention of the telephone, at Tutello Heights on the outskirts of Brantford, Ontario, and it was there that many of his experiments in multiple telegraphy, and some of the earliest in telephony were made.

"The first experimental telephone line erected in Canada and used in this connection, extended from the residence of the inventor's father across his garden. This line being found workable, it was afterwards continued on to the residence of the Rev. Thomas Henderson, in Brantford. Its successful working soon became noised abroad, and the novelty of the invention attracted many visitors from various parts of Ontario to listen to the then wonderful performance of the electric telephone; and presently, Brantford became known as the "Telephone city." At this time the much condemned "Hello" had not come into use as a signal for conversation to begin; the words "Hoy Hoy" were considered most satisfactory. We must give a discriminating public the credit of choosing the less objectionable word, and be thankful that "Hoy Hoy" did not survive.

"When the Canadian patent was issued to Professor Bell, he presented it as a gift to his father, Professor Melville Bell, and the latter, believing a company or partnership unnecessary, appointed a general agent to exploit the Bell Telephone. The latter visited the principal cities and towns and exhibited the old fashioned box telephone, with but little commercial success, however, as

the difficulty of hearing the voice clearly rendered problematic its future value as a means of communication.

"The first commercial telephone line was established at Hamilton, Ontario, in October, 1877, by the District Telegraph Company, who were quick to appreciate its value, and they therefore secured control of the invention for that district. This line connected together the residences of Messrs. Baker and Cory.

"Mr. Edison at this time was not neglecting Canada as far as telephony was concerned. He had opened up correspondence early in 1877 with the City Electrician of Montreal, and forwarded two sets of his telephones for trial. These were placed on the telegraph line between Montreal and Quebec, a distance of two hundred miles, and worked with remarkable distinctness, notwithstanding the presence of several relays in the circuit.

"On the 15th of September, 1877, a contract was entered into between these gentlemen, whereby the latter secured the sole and exclusive right to the telephonic inventions in Canada of Mr. Edison for a nominal sum, with the option of purchasing outright the patents for the sum of $10,000.

"The element of competition was thus introduced at the outset of the business. Both parties claimed priority of patents, and threatned suit against all and sundry users; but while this rivalry continued until 1880, it was not known that Edison as early as 1877 had admitted Bell's claim to priority. This he did in a letter to his Canadian representative under date of October, 13th, 1877, wherein Mr Edison stated that:

"Bell has done absolutely nothing new over Reiss, except to turn Reiss from a contact breaking into a non-contact breaking telephone with permanent magnet, and worked the thing up to a success. The records of the patent office will show that myself (Edison), Bell and Gray, started nearly together on acoustic telegraphy for Morse working; that Bell and myself dropped this for speaking acoustic, and that I dropped it first and was working on it before Bell. However, Bell got ahead of

me by striking a principle of easy application, whereas I have been plodding along on the correct principle, but harder of application.

"The cry of infringement failed to deter lessees from using the telephones, and numbers of private lines were erected in Montreal and Toronto. These lines formed the nucleus of exchanges in these cities which were first put into operation in 1878.

"Montreal was equipped with the Edison apparatus, while the local company operating at Toronto adopted the Bell instruments. The Blake and Edison transmitters having been introduced, the business began to show some development.

"The Western Union Telegraph Company, through its ally the Gold and Stock Telegraph Company, secured in 1878 control of the Edison patents for Canada, and the Montreal Telegraph Company were appointed agents for Ontario and Quebec, and the agents of the Western Union Telegraph Company in the Maritime Provinces were ordered to look after the telephone in the lower Provinces. In telegraphic circles, it was thought that whoever could control the telephone could command the bulk of the telegraph business, and the telephone was used principally as a lever to this end. The Dominion Telegraph Company, then in fierce competition with the Montreal Telegraph Company, became alarmed at the apparently shrewd move on the part of its rivals, and immediately set about securing exclusive rights of the Bell telephone as a weapon of defence. Negotiations resulted in a contract between the patentee and the Dominion Telegraph Company, and the three telegraph companies started in a race to secure subscribers to their exchanges in the cities and towns, from Windsor to Halifax, where exchanges inaugurated by local companies did not already exist. Some cities were, however, slow to appreciate the use of the telephone, notably Ottawa and St. John, N. B. At Ottawa, an active canvass was commenced, but in order to save time a complete telephone exchange outfit was shipped there; the canvass was unsuccessful; no subscribers were forthcoming, and

the plant had to be stored until the public could be educated into the use of the telephone. At St. John, only one subscriber could be secured after two weeks canvassing. A brilliant idea then occured to the manager of the opposing company at this point and was carried to a successful issue. It was to open a free telephone exchange on trial. This at once demonstrated the necessity for an exchange, and soon two competing Exchanges were working and unable to keep pace with the paying orders offered.

"This struggle between the Telegraph Companies which signally failed in its main object of diverting telegrams to any one company, resulted, not alone in cutting telephone rates to absurdly low figures, but in doing business absolutely without charge. To such competition there could be but one end, and it was soon reached. There had been a large capital outlay and the revenue did not by any means meet the expenses. A proposition at this time to form a separate Telephone Company, independent of all Telegraph Companies, was made by Mr. Charles F. Sise, the present Chairman of the Bell Telephone Company of Canada, and Mr. Hugh C. Baker, Manager of the District Telegraph Company of Hamilton. The suggestion of these gentlemen was gladly accepted by the interested companies and patentees, and by the public at large who were suffering in most cities from the annoyance ot two Telephone Exchanges. The Bell Telephone Company was thereupon organized and incorporated in 1880, when it took over all the existing plants and patents, reorganized and consolidated the exchanges, and began the manufacture of all kinds of telephonic apparatus.

"The work of constructing lines connecting adjoining places was begun on the single wire plan, and towns and villages within a radius of one hundred miles were given direct means of telephonic communication. This added to the value of the exchanges, and as the business prospered, a question was raised by interested parties anxious to embark in the business as to the validity of the Bell

patent. Two telephone companies were formed by these parties, and local competition at a few points ensued. The patent dispute was brought before the Minister of Agriculture at Ottawa, and was lost to the Bell Telephone Company in 1885. A similar fate befell the Blake Transmitter Patent, and as the Minister's decision was final and irrevocable, the telephone field was open to all comers. Notwithstanding this blow, the Bell Telephone Company continued to rapidly increase its list of subscribers and revenue, and their competitors were left to the tender mercy of their creditors, who found the venture, while it succeeded in breaking the patents, had proved an unprofitable financial undertaking. Later on competition appeared in several localities, but as the connections of these opposing concerns were necessarily limited, they again demonstrated the inutility of working a duplicate telephone system in a city or town, by disappearing from the scene without ever having paid a dividend.

"A local company was formed in Nova Scotia and New Brunswick, and after a short struggle with the Bell Telephone Company, an agreement was arrived at, whereby, each of these Provinces would have a separate telephone company, the Bell Telephone Company withdrawing from the field, but retaining an interest in each company. These companies have covered their territories with Trunk Lines and Exchanges.

"The Local Company at Prince Edward Island which had previously been formed by the Bell Telephone Company has, however, reached the highest stage of expansion, it having a net work of wires which reaches every town and village on the Island.

"The Bell Telephone Company were early in the field in Manitoba and the North West, and have kept pace with the development of this territory, by opening stations at all points where business would warrant, and by building long distance lines connecting them.

"British Columbia is served by local companies, using the same type of instrument as Eastern Canada. These companies have been most energetic and progressive in

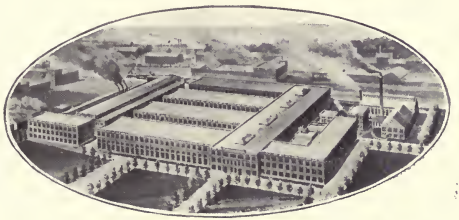
their policy. As an indication of this, we can note the fact that Vancouver, B. C., was the first exchange in Canada to alter its entire system at great cost, and give each subscriber a separate metallic line.

"Canada has kept pace with all the advances in the art of telephony. Metallic trunk lines between towns in Ontario and Quebec, were erected and put in operation when the system was first introduced into the United States, and all the best and most modern switching and signalling appliances have been furnished, this ensuring to the public a most reliable service."

The Canadian Westinghouse Company.

THE advancement of Canada as a commercial nation has been remarkable during the past few years. The new impetus has been felt in development of water powers, in mining, agriculture, transportation and manufacture, and the increment of each has reacted to swell the contribution of the others until at present Canada finds herself on a rising tide of prosperity, all the more marked in comparison with the hesitancy and stagnation apparent in many other portions of the business world.

Among the various fields of activity, that of manufacturing has more than held its own. Not only have



Works of the Canadian Westinghouse Company, Hamilton.

resident Canadians been alive to the opportunities of the period, but also individuals and corporations of other countries have been led to establish manufactories within the country, to aid in supplying the growing consumption of their products.

A highly interesting installation of the latter sort is the new plant under construction at Hamilton for the manufacture of the well known types of the Westinghouse

Electric and Manufacturing Company. From the time when electrical apparatus was first made use of in Canada, the Westinghouse Electric and Manufacturing Company of Pittsburg has furnished a large and increasing portion of this apparatus in the Dominion, until time arrived, when, in justice to their customers, it was found advisable to establish a distinctively Canadian factory to secure that intimacy of relation which is so advantageous alike to the manufacturer and client.

Passing in review the various sites suitable for the location of such a factory, it was natural that the choice should fall on Hamilton, not alone from the natural advantages of that city from the standpoint of a manufacturer, but, as well from the fact that for a term of eight years another Westinghouse interest, the Westinghouse Manufacturing Company, Limited, had been located in that centre, engaged in the manufacture of the Westinghouse air brakes for the equipment of Canadian rolling stock.

To join under one management the existing air brake business and the electric business to be instituted, a new organization was formed under the name of the Canadian Westinghouse Company, Limited; and, leaving the air brake factory in its present state of efficient equipment, work was at once started to provide a plant of modern excellence and completeness for the manufacture of electrical apparatus. Notwithstanding an unusually severe winter, construction work has been pressed throughout, until at present writing it is safe to say that an operative condition of the plant will be reached this Fall.

The Canadian Company will operate under the enjoyment of an agreement with the Pittsburg Companies, by which all designs and processes of the older companies will be at its disposal, and thus fortified with the results of years of successful experience, equipped with a plant than which no better can be found, and aided by the co-operation of many of Canada's most representative citizens, an assured future stands before the company,

and the Canadian user is assured of the best obtainable apparatus.

The lines of manufacture to be taken up comprise alternating and direct current generators; alternating and direct current motors, including railway motors; controllers; transformers; switchboards and switches; rheostats; instruments; meters; arc lamps, and the various subsidary apparatus included in the general line of Westinghouse equipment.

The new buildings provided consist of foundry, pattern shop, pattern storage, general machine shop, detail machine shop, warehouse, insulation treating building, boiler house and transformer building. On the diagram of the property shown in the illustration, these are lettered from "A" to "I" inclusive, in the order just recited, "L" is the brake plant and "K" the office building, enlarged to accommodate the increased force of the new company.

In laying out the manufacturing buildings on the property two cardinal points were kept in view—the first, that progress of material from raw to completed state should, as far as possible, be in a continuous direction, and the second, that the plan adopted should lend itself to an initial installation which would constitute a complete unit, and also be capable of reproduction along its own lines to an extent limited only by the total available property. On the latter point it may be said that something less than half of the total installation shown in the illustration is at present under construction, the northern half of foundry and warehouse, along with corresponding machine shop wings, being left for future extensions. Regarding progress of material through the plant, it may be pointed out that with raw material received on track west of the foundry, progress is in general from this point to the warehouse, from which all shipments are to be made over tracks conveniently located within the building for this purpose.

The foundry is of monitor roof construction, with middle and two side bays. In the west bay are located

the cupola house, the core room and the brass floor, while just outside along the west wall are located the bins for pig, sand, limestone, etc. A portion of the east bay is separated by partition from the foundry space to serve as a blacksmith shop. The main bay is served by a 20 ton crane, the length of the building being also traversed by travelling jib cranes, operating at a lower level. A mezzanine floor over a portion of the core room provides suitable toilet facilities without reducing productive floor space. An electrically driven elevator is provided to deliver iron from yard to charging floor, and a coke conveyor, also electrically driven, receives coke from railroad car and deposits it in an appropriate bin on the charging floor.

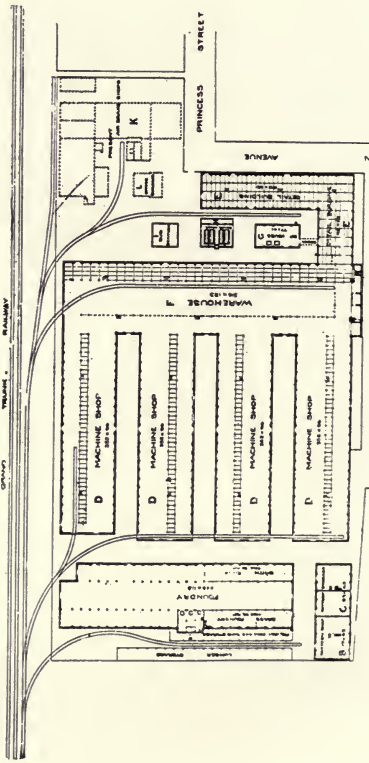
The pattern shop, located conveniently near the foundry, is three stories in height, beside a basement to accommodate shafting for machinery located on first floor. The first floor is devoted to carpenter and cabinet shop uses, while the second and third floors are for pattern making. An electric elevator serves this building from basement to top floor. The pattern storage building, adjoining, is similar in construction, except the basement, which is unnecessary.

The general machine shop is arranged with a high bay covered by 20-ton crane and low bay with 5-ton crane. In the former the heavier machine tools are located and it is here that mainly the stationary parts of generators and motors will be finished, while the low bay will be devoted to preparation of the rotary parts, and the gallery floor above the latter will provide space for the manufacture of commutators, brushholders, bearings, etc., also for tool room and controller department. Toilet rooms and heating and ventilating fans are placed on a narrow mezzanine floor between the high and low bays, the same being reached by stairways from both the ground and gallery floors. The elevators also pass up through this floor and industrial tracks run under the mezzaine, along by the foot of the elevators on the ground floor. After the completed rotary part has received its winding at the eastern

end of the low bay it is passed by jib crane under the mezzanine floor at this point on to the eastern end of the high bay, where it is placed in its corresponding stationary part, which has been under construction in this aisle. and the auxiliary parts are received at the same point by elevator from the gallery floor. In addition to the crane serving the main portion of the high bay, this eastern end or assembling floor is provided with an additional crane of like span, but at a lower level, so that by it machines can be delivered from the assembling floor, through under west gallery of warehouse into middle bay of the latter building, where the north and south crane can pick up the load for further handling.

The warehouse has a high bay in the middle, with one gallery on the west side and two galleries on the east side. The machines delivered, as just described, from the general machine shop, are passed to the testing floor on the west side of the main bay and after test are finished, painted and shipped on cars from the warehouse track. This track also is the means for entry into the plant of the less bulky material and supplies, which are stored in this building for ready distribution to both the general and the detail machine shops. The floor east of the tracks is at car floor level to faciliate handling of such material, and elevators are of course provided for distributing to the various floors.

The detail machine shop has two floors thoroughout, beside the ground floor at levels, corresponding to the two galleries on the east side of warehouse, with which they directly communicate. It should also be noticed that the top floor of this building is at the same height as the gallery in the general machine shop and the west side of warehouse, and that a connecting gallery at the same height is carried around the south end of warehouse building. On the ground floor of the detail machine shop the coil winding and insulating departments are located, this being convenient both for receipt of wire from warehouse and delivery of completed coils to winding and assembling spaces at east end of general machine shop



Plan of Ground Floor, Canadian Westinghouse Company's Works Hamilton.

already referred to. The second floor is devoted to the machine work necessary on switches, rheostats, meters, instruments, arc lamps, etc., and on the third floor are the assembling and testing rooms for these lines of apparatus. No cranes are needed in this building but elevators are provided, securing easy access to various floors.

The insulating-treating building is separate from the main group, so that this work, involving use of inflammable materials, can be isolated. Convenient communication with the detail building is provided by a two story enclosed bridge cut off at each end by fire doors.

The boiler house, it will be noted, is small in comparison with the main plant, which is due to the fact that the use of steam will be largely restricted to heating and drying purposes. Most of the steam for drying will be used in the insulation-treating building next adjoining, but for heating the buildings it will be piped to nests of coils suitably installed in each building, with fans to distribute the air heated by these coils.

Power for manufacturing and testing purposes, as well as for lighting, is to be obtained from the Cataract Power, Light and Traction Company. Current will be received in the transformer house at 2,400 volts, and distributed at 440 volts for general shop purposes, although lighting distribution will be at 110 volts, and transformation to direct current will be made to supply some of the cranes and machine tools.

The construction of the buildings, which is in the hands of Westinghouse, Church, Kerr and Company, of New York, as engineers and general contractors, is of the most modern approved type. The foundations and walls up to window sill line are of concrete, above which the walls are of brick, laid up in cement mortar. Floors and roofs are of reinforced concrete throughout, and in detail machine shop and pattern buildings even the columns are of this construction. The result is a group of buildings as desirable and as nearly fireproof as it is possible to make them. All roofs are practically flat, with drainage so arranged that the leaders are carried down through the

interior of the buildings to avoid stoppage by freezing in cold weather. Floors are top dressed with 1 inch maple and roofs with tar and gravel.

Transportation between the foundry and all buildings, including the air brake plant, will be by industrial railway, operated by storage battery locomotive. The standard gauge tracks on the property are directly connected with main line of the Grand Trunk Railway for receipt of material and shipment of product. The main entrance to the plant, for employees, is at the south end of warehouse building, a central point at which will be located time checking devices, and from which stairways lead directly to the various floors. Entrances for teams from the city streets are provided near west end of machine shop and in front of the office building.

The equipment of the plant will be on the most modern approved lines, as developed by experience of the Pittsburg factories.

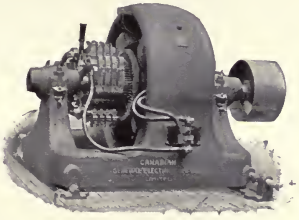
Canadian General Electric Company, Limited.

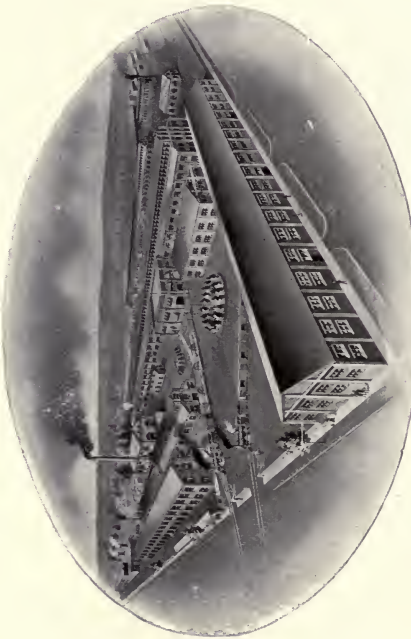
FEW engineers except those directly interested realize the magnitude to which the Electrical enterprises in this country have developed. It has been a matter of great difficulty to keep pace with the rapidly growing demands, and in order that Canadians may reap the advantages of home production the Canadian General Electric Company have recently enlarged their extensive works at Peterboro, of which the accompanying illustration gives a very good idea.

The plant occupies about forty acres and is one of the finest manufacturing enterprises in the country.

The largest building is the Machine Shop, having a total area of 81,232 square feet, and is equipped with the most modern machinery. The building is about sixty feet high with a gallery on each side of twenty-five feet.

There are numerous other buildings in which the several branches of the manufacturing of Electrical apparatus and supplies is carried on, comprising the Electric Shop, Amateur Shop, Lamp Works, Wire Works, Blacksmith Shop, Brass Foundry, Pattern Shop, Stores and Compound, Carbon and Porcelain, and several other buildings, of which the

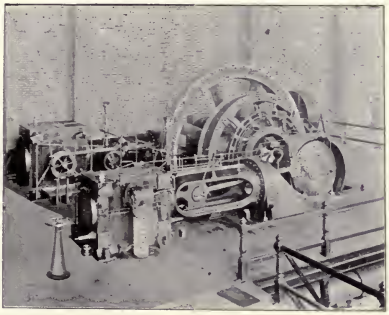




Canadian General Electric Company's Plant at Peterboro.

limited amount of space will not permit a detailed description.

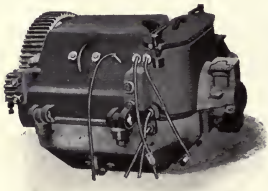
A new Steel Frame Building of the most modern construction, 450 ft. x 80 ft. has recently been added which



will be used as a Stores Department, besides large extensions to several of the other shops.

The motive power is obtained from the Company's plant at Nassau, about six miles distant, which has a capacity of about 1500 horse power. The water wheels are of the Horizontal Turbine type and to them are direct connected two 450 K. W., three-phase revolving field generators operating at 138 R.P.M and genera-

ting Current at 60 cycles and 6,600 volts. The current is transmitted to the works on two three-phase lines constructed of No. 1 B. & S. copper wire in the triangle form, one circuit on each side of the pole. Four feet below the transmission wires is placed the telephone line consisting of two No. 8 copper wires suitably transposed to prevent induction, thus keeping the works in close touch with the Power House.



There are here in course on construction for Niagara Falls, a number of the largest generators in the world, each having a capacity of twelve thousand horse power, also a large amount of generators and motors of varied horse power, Curtis Steam Turbines for direct connection to alternating and direct current generators, etc.

The shipping facilities are unexcelled. There are nearly twenty buildings all reached by track, and raw material or finished product is delivered or taken away by way of switches to the main tracks of the Canadian Pacific Railway or the Grand Trunk Railway Systems.

All the buildings are equipped with the most modern facilities for handling raw and finished material. Several large electric cranes of large tonnage, also jib and portable cranes, are placed all through the shops to facilitate the handling of the product. These conveniences combined with the excellent light, ventilation and sanitary conditions, make it one of the best equipped plants on the Continent.

Canada Foundry Co., Limited.

THE Works of the Canada Foundry Company at Davenport, Ontario, just outside the limits of the City of Toronto, are one of the finest examples of Shop Engineering on the Continent. They occupy an area comprising sixty acres, with shipping facilities that are unexcelled.

The buildings contain at present 258,140 square feet, or six acres of operative floor space divided among Structural Steel Shop, Bridge Shop, Blacksmith Shop, Machine Shop, Boiler Shop, Foundry, Pattern Vault, Warehouse, Storage and Pattern Shop, Machine Screw Department, and several other buildings.

The Canada Foundry Company's Plant at Davenport, Ont.

The shops are fitted throughout with all the most modern machines required for the construction of Steam and Electrical Locomotives, Boilers, Engines, Railway and Highway Bridges, Electric Travelling Cranes, Rail-

way Trucks, Pumping Machinery of every description, Water Works Supplies, Architectural and Decorative Metalwork of all styles and finishes, and many other lines.

In a separate power house is generated all electric power used on the premises. The shops are all well lighted and ventilated, and the sanitary arrangements are unsurpassed in excellence. The plant being equipped throughout with the most modern appliances.

Shawinigan Water and Power Co.

THE works forming the subject of this sketch are located at Shawinigan Falls, Province of Quebec, about half way between Montreal and Quebec, and about twenty miles north of the St. Lawrence River, in Montreal and along the country between.

Shawinigan Falls is a cascade in the St. Maurice River over which its waters flow through a fall of about 150 feet. The St. Maurice River was visited by the

Shawinigan Falls.

earliest explorers. A settlement was made at its mouth known as Trois-Rivières in the days of Champlain, about 1630. The river formed one of the early routes into the Hudson Bay country. After the portage at Shawinigan and one at Grand Mère, about six miles above Shawinigan, the river is navigable for boats of considerable size for upwards of 75 miles.

By this route it is possible to penetrate into the wilderness about 350 miles from the St. Lawrence. From this

point, a comparatively short portage leads to the lakes and large river flowing into the St. James Bay, about 300 miles farther north. This route was early established as the principal route to Moose Factory and is still so used.

Notwithstanding this fact, the power at Shawinigan Falls was not used, and the region immediately adjacent was a wilderness until after the purchase of the water power and the surrounding lands in 1897. The Shawinigan Water and Power Company was organized

General View of Plant.

soon after these purchases, and now owns upwards of 2,000 acres of land on both banks of the river, covering the whole country adjacent to the Falls.

The St. Maurice River above Shawinigan Falls drains a tract of country reaching north to the divide between the St. Lawrence and Hudson Bay Valleys, and extending from Lake St. John on the east to sources of the Gatineau, lying practically north of Ottawa upwards of 18,000 square miles in area.

The country is heavily wooded and thickly interspersed with lakes. The snow in winter covers this

country to a depth of 6 to 10 feet, and reaching as far north as it does, the effects of the melting snow does not cease to be felt at Shawinigan until late in June. The numerous lakes store the waters to such an extent that the flow of this river is very regular, and seldom falls below 10,000 feet per second, which, under the available head of about 140 feet is sufficient to produce upwards of 100,000 horse-power.

The formation at Shawinigan Falls is especially adapted for the development of water power. Immediately above the Falls, the river broadens out into a lake some 4½ miles long, and over ½ mile in width. Immediately below the Falls is another lake of still larger dimensions. For about 1,000 feet above the crest of the Falls, the river narrows down to a width of about 600 feet, and a depth of about 20 feet. West of this channel, the ground is practically level and of hard granite formation.

The Canal.

From the western edge of this level a steep slope of hard granite rock reaches down to the level of the lower lake in a distance of about 500 feet.

In making the power development at Shawinigan Falls, the water was taken out of the comparatively narrow channel of the river, because in the spring large quantities of ice flow down the river, and the location of a canal was decided upon with a view to avoiding trouble from this cause, as well as to obtain the most substantial construction. The canal is about 1,000 feet in length, 100 feet wide, and 20 feet deep; throughout its length the surface of the rock is at the low water level. Along the north side of the canal a dry wall has been built from the surface of the rock to a point above high water, and on the south side a timber crib has been built with view to possible enlargement. The canal is closed at its west end by a concrete wall 40 feet in height, containing openings for six penstocks 9 feet in diameter. The intention is to extend this wall farther to the south forming a wider forebay from which additional penstock will be taken to a number sufficient to utilize the full power of the river.

Gate House.

On top of this forebay wall, a brick gate-house has been constructed, in which is installed cylinders for raising and lowering the head gates closing the upper end

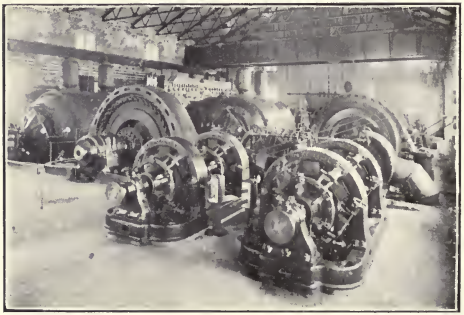
of the penstocks. This hydraulic mechanism is designed to work under a maximum pressure of 800 lbs. per square inch, and successfully operates the steel head gates under pressure of 40 feet head of water. Four penstocks 9 feet in diameter have already been installed. The first one of these penstocks leads to the power house belonging to the Northern Aluminum Company, who purchase the water at their power house, and who have installed their own wheels and generators with which to generate the direct current suitable for their uses. The other three penstock pipes lead to the main power house of the Shawinigan Water and Power Co. There is also a penstock pipe leading to the same power house, 3' 6" in diameter, conveying the water for operating two separate turbines of 500 H. P. capacity, each for driving the exciters.

The tail race is also excavated from the solid rock and extends back from the Shawinigan river about 500 ft. The bottom of this excavation is about 136 ft. below low water level, giving an actual working head at present of about 130 ft. at lowest water, or an ordinary working head of about 135 ft. It is proposed to raise the low water level by means of a dam at the crest of the Falls, maintaining the water level of about 15 ft. above present low water, at all times giving an ordinary working head of 150 ft. The excavation underneath the power house is carried down some 8' lower than the bottom of the tail race, giving sufficient depth for proper discharge and insuring the sealing of the draft tubes.

From this excavation, the basement of the power house is built carried upon concrete arches over the tail races. All the walls of the basement are of concrete made water tight, in view of the fact that the water in the lower bay sometimes rises nearly to the main floor of the power house which is 28' above the bottom of the tail race. Above the main floor of the power house, the building is of brick.

There is installed in the building an electrically operated crane of 50 tons capacity serving the entire floor. There are at present installed in the main power house,

three pairs of turbines one connected directly to each of the 9 ft. penstock pipes. These turbines each consist of a pair of inward discharge Francis wheels in a steel case, operating at a speed of 180 R.P.M. and capable of delivering 6,000 H.P. The two wheels first installed were built by the I. P. Morris Company, of Philadelphia and have stationary guides and no gates on the high pressure side. They are controlled by butterfly valves in the draft tube handled by a combined governor. The third wheel was



Interior of Power House.

built by Escher, Wyss & Co., of Zurich and is similar to the other two, except that it has movable guides. The speed is regulated by a hydraulic governor using water at the penstock pressure.

There is direct connected to each of the three wheels, a generator of the Revolving Field Type of 3,750 K.W. capacity, generating 30 cycles, 2-phase, 2,200 volt current. The first two generators were built by the Westinghouse Electric & Manufacturing Co., of Pittsburg, and the third by Dick, Kerr & Co., of London.

The water wheels and generators operate on a horizontal shaft and are set in two lines in the power house,

the shafts extending lengthwise in the power house and the units stagered so that the penstocks leading to the wheels of one pass the end of the wheel in the other. A fourth unit is now being installed which will have a water wheel of a capacity of 10,500 H.P. taking water through a penstock 12 ft. in diameter which is now being constructed. This wheel differs from the other three wheels in that its case will be out of the spiral type taking water below the shaft and discharging outward through two draft tubes connected to the wheel case by quarter turn. The runner, although practically a pair of wheels, is made in one piece, the backs of the two wheels being, as it were, joined together so that the water passes through one set of gates and entering the runner is divided by the central rib and discharges outward on two sides. It will be fitted with movable guide gates, which will be handed in the usual manner by two rings passing around the outside of the wheel with which the outer ends of the gates are connected. These rings will be moved by rods which pass upward from the circumference of the ring through the case, each having on its upper end a piston moving in a cylinder 36" in diameter and operated by penstock pressure. These cylinders will be operating cylinders connected to a hydraulic governor. The gates of this wheel will be 24" in length, enabling the water wheel to take a sheet of water 24" around its entire circumference. The wheel case will be about 30' in height from its foundation to the top of the operating cylinders. Its shaft will be 36" in diameter at the centre, 16" in the bearings and about 40 ft. in length. It was forged from a single ingot at the Bethlehem steel works. The steel runners and gates, as is the case of the runners and gates of the other three pairs of wheels, will be built of bronze. The wheel is being built by the I. P. Morris Company of Philadelphia.

The generator is being built by the Westinghouse Electric & Manfg. Co. and is similar to the other three generators, except that it has a capacity of 6,600 K.W.

Each of the two 500 H.P. wheels has connected to it a

direct current generator of 400 K.W. capacity at 125 volts which are used as exciters. The current from these exciting generators is conducted over aluminum busbars from the generator to the exciter panels, located as are the balance of the panels, upon a switchboard gallery running the entire length of the building and about six ft. above the main floor. The space underneath this gallery is open to the basement floor and in this space are located the electrically operated oil switches.

The current from each generator is conducted to the generator switch by paper-insulated, lead covered cables in tile ducts built into the floor. There is installed back of the oil switches and underneath the switchboard gallery a double set of busbars. The cables pass from the oil switches to a selector switch by means of which the current can be thrown on to either one of the two sets of busbars the plan being to separate the load which is subject to fluctuations from the more steady load by means of two sets of busbars. This is accomplished by means of the selector switches which are of the blade type and are arranged so as to be electrically interlocking with the main generator switch, so that the generator switch cannot be thrown unless all the selector switches are closed in such a way as to throw all the leads they control on to the same set of busbars. The selector switches cannot be opened unless the main switch is open.

All of the cables in the power house which are not placed in tile ducts are carried on porcelain clamp insulators on iron frames and separated by each other by barriers about 1" thick, made of concrete with expanded metal embedded. From the busbars, the current for local small power work is conveyed on lead covered cables at 2,200 volts to a lightning arrester house and thence on overhead lines to the points of use. The current for larger factories, located two miles or more from the power house up to a distance of 20 miles, is conducted from the busbars through oil switches to step up transformers, stepping up to 25,000 volt, 2-phase and thence through lightning arresters and overhead lines to the points of use. The

current designed for greater distance is taken from the busbars through oil switches to the transformers stepping up to 50,000 volts and changed to 3-phase, passing through the static interruptors and lightning arresters to the overhead lines.

The transformers are located in a building back of the power house and extending over the tops of the penstocks. The building is of brick on stone foundation, floor being of concrete, the roof of steel, making a plain and entirely fire proof building. The transformer house contains no crane. The transformers each have two rails built into and forming apart of the cast iron bed. The

The Transformers.

rails rest on two rows of flange wheels, the wheels being supported upon masonry foundation, being free to rotate but held in a fixed position. In front of the transformers are two rails built into the floor. On these rails is a steel truck, the top of which is level with the transformer foundation. In the truck are two lines of wheels similar to those upon which the transformer rests and set at the same gauge. When the truck is placed in front of any transformer, the transformer can be drawn off from its

base on to the truck and the truck moved along the track to the end of the building where the means for dismantling are provided. This method of operation leaves the overhead part of the transformer house free for the high tension wiring. It is cheaper than a crane and answers this purpose equally well and what is most important does not interfere with the wiring. The transformers are oil insulated, water cooled type having a rated capacity of 1,110 K. W. They can carry steadily a large overload.

The transformer cases are built of boiler iron and are designed to have attached to them a device for protection against possible explosion or fire in the transformer room. This device was designed by Mr. Ralph D. Mershon, the consulting electrical engineer of the Shawinigan Water & Power Company and is described by him in a recent article in Cassier's Magazine, as follows :—

"To the center of the lid of each transformer tank is connected a large pipe leading to the sewer. At the bottom of the tank is another pipe connected to the source of water supply and closed by two valves in series, between which is a small drip cock to prevent the possibility of water entering the transformer tank through a leaky valve. The lid of the tank is fitted carefully to the tank itself with gaskets, and all conductors passing through the lid are brought out through stuffing boxes so that the tank is practically air-tight, except as regards the vent from the middle of the lid through the pipe into the sewer. The tank and all its fittings are built to stand the maximum pressure which could be generated by ignition of any mixture of air and oil vapour which might collect over the surface of the oil. The tank itself is, therefore, amply strong enough to stand the force of an explosion, and, in addition, there is the vent from the top to the sewer to relieve and keep down the pressure of any explosion which might occur.

If, after trouble in the transformer, the oil should continue to burn, making it desirable to get the oil out of the tank, the water valves at the bottom of the tank may be opened, thus admitting water to the tank and forcing the

oil out of the top into the sewer. This is a much safer way of emptying the tank than by the usual means of a valve at the bottom, since in the latter case air must be drawn into the tank as the oil passes out, making possible the formation of an explosive mixture and risking the danger of an explosion. Even if the oil were not burning, there is more or less danger in drawing it out of the bottom of the tank, since the explosive mixture formed thereby would be ignited by any smouldering bits of insulation which might be present.

The use of the water would not be resorted to except in an extremity, but it is believed to furnish in case of such extremity a safeguard much more effective than anything else which has been proposed. If the water be used, it will not necessarily do any great damage to the transformer, especially if it be not allowed to remain long in the transformer tank. An oil-soaked transformer will not readily take up water, and such water as it does take up can be dried out. The transformers in most cases will have to be dismantled for repairs, and the dismantling will make the drying out more easily and quickly accomplished. With the transformers installed in the manner described, it is believed that no serious damage could result from either an explosion or fire."

In the basement of the transformer house are provided two tanks, each capable of holding 1,500 gallons of oil, which is the amount contained in each transformer. One of these tanks is kept full and the other empty to receive the oil which might be desirable to empty out from any transformer. There is provided a motor driven pump for filling the transformer from either of these tanks.

From the high tension terminals of the transformers the current passes to the high-tension busbars through long-break knife switches, which may be operated by a pole from the floor, and are intended as a means of connecting or disconnecting the transformers from the busbars under conditions of no load. These are the only high-tension switching devices employed. These switches and the high-tension wiring are mounted on line insu-

lators supported upon a suitable wooden rack suspended from the roof trusses of the station. From the high-tension busbars the high-tension wires pass through static interrupters, consisting of oil-insulated condensers and choke coils, and then out of the building through large sewer tile set in the wall and closed by glass plates pierced in the centre by holes for the line conductor.

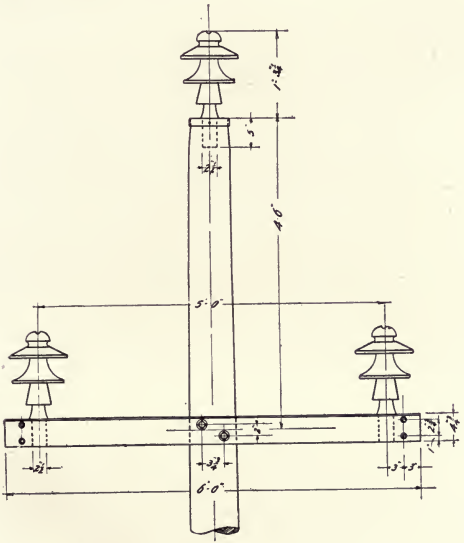
At a point just before the line passes out of the building, are connected the lightning arresters, consisting of three slabs of marble, one for each line wire, on which are mounted low equivalent, non-aecing metal lightning arresters. Between the static interrupters and the lightning arresters are connected two ground detectors, one from the middle wire to one outside wire, and the other from the middle wire to the other outside wire. The ground detectors are not directly connected to the line conductors, but receive current through the medium of sleeve condensors, one on each line wire.

The total length of the transmission line from the generating station at Shawinigan Falls to the terminal station in Montreal, is 84.3 miles. It consists of three aluminum cables, each composed of seven No. 7 aluminum wires. The total drop in the transmission line when 8,000 horse power are being delivered to the customers' busbars in Montreal is, at unity power factor, about 18 per cent. of the delivered voltage, requiring about 50,000 volts at the generating station. By operating at a higher drop, considerably more power may be transmitted over the line, and it is possible to do this with the present installation since, as mentioned elsewhere, the step-up transformers are capable of operating at considerably over their rated voltage.

The three line cables are arranged in an equilateral triangle, the distance from centre to centre of the cables being 60 inches. One of the cables is carried on top of the pole and the other two at the end of a cross-arm. The insulators were specially designed for this plant and this voltage. Before shipment all of them are given a salt water test of 100,000 volts for one minute.

They are of porcelain, and are in three parts, held together by Portland cement. The poles are of cedar, and are set generally 100 feet apart, although where necessary the span has been increased to 200 feet. Each pole is bored in the top for the top pin, and the top of the pole is surrounded by an iron band driven tightly on to prevent splitting. The cross-arms are of southern pine, treated by dipping in a hot, weatherproof, and preserving mixture. The pins are of hickory, treated by boiling in stearic acid.

The transmission line is transposed at two points at approximately ⅓ and ⅔ of the total distance. It was



Pole Head.

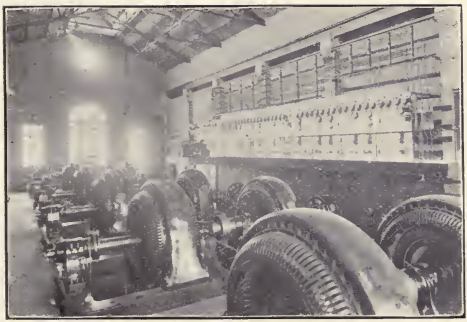
constructed with a telephone line on the same poles which has operated successfully, except that in cases of accident resulting in the dropping of one of the transmission lines, the telephone line is usually destroyed at the time when it is most needed. It has, therefore, been decided to remove the telephone line, and build same on a separate pole line.

Transmission Line.

A second transmission line is now being constructed, similar to the one described, except that the cables will be composed of seven strands of No. 4 wire.

Both of these lines will enter a high-tension room in the terminal station at the city line of Montreal. Entering the building in the same manner as above described for passing out of the transformer house at Shawinigan Falls, through the same lightning arresters, and static interruptors, and through knife switches to a connection with high tension busbars as above described. The step-down transformers are of the same type as the step-up transformers, being 1,000 K. W. in capacity, and designed to reduce the current from 44,000 to 2,400 volts, both 3-phase.

At Montreal the Company has contracted to deliver to the Montreal Light, Heat and Power Co., current at 60 cycles. It is necessary, therefore, to install motor generators to change the frequency. There are at present installed five of these sets of a normal capacity of 800 K. W. each, which consists of a 3-phase, 30 cycle, 2,400 volt synchronous motor, direct connected to a 3-phase, 2,400 volt, 60 cycle generator. Each set has mounted on the same shaft exciter for the whole set, which is also used as a starting motor.



Interior of Terminal Station at Montreal

The current for starting is taken from an auxiliary set, consisting of a 75 K. W. compound wound direct current generator, direct connected to a 30 cycle, 3-phase, 2,400 volt motor. This small motor generator set may be used as an exciter for any set in case of accident to the direct connected exciter.

There is also now being installed a similar set having a capacity of 4,000 K. W. similar in all respects to the 5 smaller sets above described, except that it is provided with a 3-phase, 30 cycle, 2,400 volt starting motor, and is

excited by a separate 200 K. W. set of the same characteristics as the 75 K. W. set just described.

The switchboard for controlling the transformers and frequency changers is mounted on a gallery extending along one side of the motor generator room. The oil switches, one for each pair of transformers, are installed on the opposite side of the room on the main floor. The oil switches for the motor and the generator, and the motor generator sets are installed in the basement, as are also the rheostats.

Current is conducted from the transformers through the oil switches to 30 cycle busbars installed on a steel frame supporting the switchboard and back of the board, level with its top. From these busbars the current is taken for each motor through oil switches installed in the basement on lead covered cables. From the generators the current is conducted through oil switches and lead covered cables to knife switches, which may be connected to either of two sets of busbars, and from these busbars to the busbars of the Montreal Light, Heat and Power Co., in their adjacent distributing room.

It is designed to deliver current from Shawinigan not only to Montreal, but to other towns between Shawinigan and Montreal. One branch line has already been built, which branches off from the main line at the town of Joliette about 50 miles from Shawinigan. At this point a transformer house is installed containing oil insulated natural cooled transformers, stepping down from the voltage on the main line to 12,500 volts. At that voltage 500 H. P. is now being transmitted to the town of Sorel on the south shore of the St. Lawrence river, crossing the river by means of submarine cables. At Sorel it is stepped down to 2,200 volts for distribution for light and power in that city.

The main reason for using the 12,000 volts on this line was on account of the necessity of crossing the river with cables. Power is also taken off from this branch line at the town of Lanoraie on the north side of the St. Lawrence river. Arrangements are being made for establish-

ing other sub-stations along the main line. Connections will be made at these sub-stations so that current may be taken from either transmission line, connections being made by means of knife switches.

Work was commenced upon the plant at Shawinigan Falls in May of 1899. The first plant, that of the Pittsburg Reduction Co., was started in October of 1901. Contract for delivery of power in Montreal was made in May, 1902, and the first block of 2,000 H. P. was commenced to be delivered on February 3rd, 1903, and the total amount of power now being delivered in Montreal is something over 6,000 H. P.

INDUSTRIES AT SHAWINIGAN FALLS.

In addition to the supplying of power for transmission to Montreal, as above-described, the power is also supplied for use of various industries near the power house.

The Northern Aluminum Co., manufacturers of aluminum, was the first industry to establish itself at Shawinigan Falls. This Company, as above-stated, take their supply of water from one of the penstocks leading from the canal of the Shawinigan Water and Power Company, and are expected to take the capacity of another penstock, the opening for which has been left in the forebay, and the use of which has been provided for in their power house.

The business of the manufacture of aluminum requires the use of direct current at low voltage, and at Shawinigan being able to locate their factory near to the power house, it was considered better to generate the power as direct current, rather than to take power from the Shawinigan Water and Power Co. as alternating current, and convert the same to direct current at their factory.

The power house is located on the east side of the tail-race, as appears in one of the illustrations. They have at present installed 3 water wheels, each driving two direct current generators, one being coupled to each end of each water wheel shaft. The three wheels are supplied with water from one penstock. It is

intended to install two additional wheels, and also an additional penstock. The plant will then be so arranged that two of the wheels will be connected to each penstock, and one wheel, the centre one in the power house, will be connected with both penstocks with valves in the supply pipe of each wheel, so that in case the water is shut out of either penstock, three wheels will be available for use.

Each of the wheels of the Northern Aluminum Co. consists of a pair of inward flow turbines which take water at the bottom of the case, and discharge it through quarter-turns and draught tubes at each end of the case. Each wheel is provided with a valve at the intake, by means of which the water can be shut off from it while the others are in operation. The direct current from from the generators is carried directly to the reduction room—a total length of 700 feet—over aluminum rods ⅜ inch in diameter. The conductors on each side consist of 200 of these rods.

The aluminum works consists of several large buildings of standard iron and brick mill construction in which are located the various branches of the works.

Probably the most interesting is the reduction building in which are located the electric furnaces for reducing the ore. The process used is the well known Hall reduction process of which no description is necessary.

Besides the furnace department are others devoted to the grinding, mixing, and the shipping department where the aluminum is boxed up for shipment.

Recently, the Northern Aluminum Co. installed a wire drawing and cabling plant which has already completed some very large orders. All of the aluminum cable used by the Shawinigan Water & Power Co. was made by the Northern Aluminum Co. at Shawinigan Falls.

BELGO-CANADIAN PULP COMPANY.

An industry for which Shawinigan is particularly adapted by reason of the great quantities of spruce wood

on the St. Maurice River, and its tributaries is the manufacture of wood pulp and paper. The second industry to establish itself at Shawinigan was the Belgo-Canadian Pulp Co., which Company was organized by Belgium capitalists.

The operation of paper mills, especially the wood pulp grinding department, is most economically accomplished by means of water wheels located in the factory. For that reason, this Company desired to receive its power in the form of water delivered into its mill, and, therefore, the Shawinigan Water and Power Co. made a separate development for the purposes of this mill. At a point about half a mile up the river from the main canal, and along the shore of the upper lake, there is a distance of less than 1,000 feet from the shore of this lake to the Shawinigan River which flows into the lower lake, and at this point is of the same elevation as the lower lake. It is, therefore, at this point possible to obtain the same fall as obtained at the main power house, by conducting the water in penstocks a distance of about 1,000 feet. The depth of the water in the upper lake is, at this point, something over 20 feet, and here the Shawinigan Company built the head works of sufficient size to take water for about 15,000 horse power. The construction necessary was accomplished by unwatering the shore of the lake for a length of obout 250 feet, and for about 100 feet out into the lake from the shore. This unwatering was accomplished by means of a coffer-dam, which it was necessary to make tight against high water, which was about 40 feet deep at that point. The coffer-dam consisted of a crib-work construction secured by piling, and for means of protection against ice was made a permanent structure, the water being taken through 12 openings in the bottom of the crib, about 10 feet square. This crib was sunk in place, made tight against the shore and pumped out, and a concrete wall about 40 feet high containing the racks and head gates were built near the shore.

The material at this point is entirely clay for a great depth, and it was desired to strengthen the shore of the

bay, and for that purpose cribs and piling were constructed each way from the coffer-dam above-described, and filling is being made behind them.

The headworks are designed for two penstocks 12 feet in diameter. Only one penstock has been installed for purposes of furnishing water to the pulp mill.

The distance through the clay bank at the low water level is 200 feet, and the construction of this part of the penstock was by means of a tunnel which was timbered, and after the penstock was installed was filled inside the timbering with concrete. From the outer end of this tunnel the penstock is carried down through a ravine to the paper mill located on the shore of the Shawinigan River. The pulp grinding department which was established and put in operation first, consists of grinders driven by separate water wheels, two grinders direct connected to each water wheel. The operation of the grinders and other appurtenances of the pulp mill being driven by separate water wheels. One paper machine of a capacity of 25 tons per day has been installed, and additional paper machines are expected to be installed in the near future.

SHAWINIGAN CARBIDE COMPANY.

At a distance of two miles from the power house of the Shawinigan Water and Power Company, on the banks of the St. Maurice River, the Shawinigan Carbide Company have constructed a plant for the manufacture of Calcium Carbide.

Power is supplied from the power house of the Power Company at 25,000 volts, the step-up transformers being identical with those used on the 50,000 volt line, changes being made in the connection of the secondary coils so as to get half voltage on the transformers; by this means, all transformers in the building are duplicates.

At the Carbide Company's transformer rooms are installed 12-300 K. W. oil-filled, self-cooling transformers stepping down from 25,000 volts to 75 volts. Besides these, there are two power transformers for driving motors,

etc., around the building. These motors operate the crane, crusher, mixers, and a very complete system of dust collectings and distributing apparatus, besides conveyors for conveying the material into the furnaces and into the works.

Calcium Carbide is a combination of calcium and carbon expressed by the chemical formula, CaC_2.

In the commercial manufacture of this substance, the calcium is obtained from lime and the carbon from coke. A mixture of these two substances is heated to a high temperature in an electric furnace—the calcium and carbon combining when fused, to form calcium carbide.

Previous to being put in the furnace, the lime and coke have to be ground to the right size and thoroughly mixed.

One peculiarity about Calcium Carbide is, that in a fused condition, it becomes a good conductor of electricity. The carbide comes out of the furnace as a hot, hard mass, which has to be broken up and crushed in various sizes for market; it is then packed in hermetically tight tin cans for shipment.

THE ELECTRO MANGANESE COMPANY.

The Electro Manganese Co. are engaged in the manufacture of ferro manganese.

Pending the erection of their own plant, the Electro Manganese Co. are using one end of the furnace room of the Shawinigan Carbide Co. Here they have erected two large electric furnaces and by a secret process are making ferro manganese. This substance is used principally in the manufacture of high grade of steels.

The ore for the manufacture comes from the Company's mines in New Brunswick.

TOWN OF SHAWINIGAN.

Owing to the establishment of these various industries, a town has grown up on the shore of the upper lake, having a population of some 3,000 people.

The town has two banks, two churches, several hotels,

a complete electric light system, and a very good water service. The pumping plant is worth a visit as it represents the most modern practice of motor-driven pumps, suitable for fire pressure when necessary.

Besides the various industries enumerated above, the town is engaged in lumbering and has several planing mills.

There is a flourishing brick yard from which most of the brick used in the works and town has been supplied.

Five years ago the site of the town was uncut forest. Now it is a thriving city, looking confidentially forward to the time when it will be a great manufacturing center.

Allis-Chalmers-Bullock, Limited.

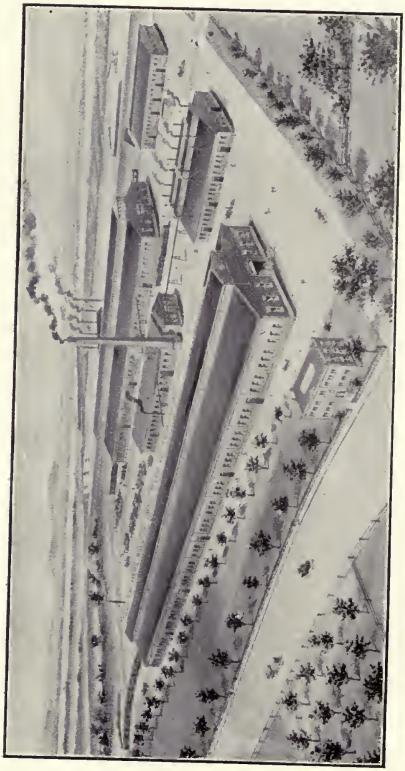
THE rapid developments which have taken place in Canada during recent years, have forced American Manufacturers to realize the necessity of establishing branch factories here in addition to their representative sales offices, in order that they may more readily supply the increasing demands, and more fully assist and perfect the remarkable growth of the country. Especially, is this true of the makers of Hydraulic Electrical and Mining Machinery.

It has only been a short time since the business would warrant large investments in Canadian factories, but the development of the great natural water powers and the opening of the North West with its wealth of farming country and mining property, has made the world realize the possibilities of the Dominion.

Allis-Chalmers-Bullock, Ltd., is one of the companies most recently organized to supply the increasing demand for power machinery of all kinds. To the uninitiated, its name does not convey an adequate idea of the varied interests which it represents, but a glance at the organization leaves little to be desired in its strength and breadth.

Foremost among the companies which it represents is the Allis-Chalmers, Co., which in itself is a consolidation of four great companies, and which is recognized as a pioneer and leader in the development of power by means of steam, gas, and water, and also in the manufacture of mining and mill machinery.

While steam gas and water have long been considered indispensable there is another power, that of Compressed Air, which is all the time being more fully appreciated as an important factor in the world's progress. In fact its advent in the industrial field has revolutionized many old time methods. The advance of this branch of engineering has been largely due to the Ingersoll Sergeant Drill Co., which has so long been recognized as a leader in this class



of work. The apparatus of this Company together with that of the Lidgerwood Mfg. Company, has been manufactured in Canada for a number of years, and in acquiring their works property, Allis-Chalmers-Bullock, Ltd., absorbed the Canadian interests of these companies.

Not many years ago power was developed, manufacturing carried on, and mines were operated with only the powers refered to above; but how different is the situation to-day when not a single industrial art is practiced without the aid of that evermore wonderful power, Electricity. In this most important branch of engineering, Allis-Chalmers-Bullock, Ltd., represents the Bullock Electric Mfg. Co., whose remarkable and unqualified successes and advancement have placed them in the highest rank of Electrical engineers and manufacturers.

This new Company whose organization is outlined above will work in the closest relation to the American Companies, and with the benefit of their wide experience, will manufacture machinery of the identical design and of the same high grade material and workmanship.

The works of the Allis-Chalmers-Bullock, Ltd., are situated at Rockfield, Que., near Montreal. The site is ideal, there being shipping facilities by the Grand Trunk Railway, the Canadian Pacific Railway, and the Lachine Canal. The property is about fifteen acres in extent, and at present there are on it five shops. All the buildings are of the most modern and improved construction, and there is every facility for the handling of the work. The main machine shop is a building 400 ft. long and 100 ft. wide, divided into a centre and two side aisles. In the centre are the heavy tools and heavy assembling department, while the smaller tools and detail departments are in the side aisles. The tool equipment is excellent and is to be further improved by the addition of many new tools especially adapted to the class of work to be carried on. It is intended to extend this shop and to erect beside it a twin shop, the two to open into a large assembly and store room, fully equiped with cross tracks and travelling cranes for the handing of all material. This, when com-

pleted, will make a machine shop seven hundred feet long and two hundred feet wide.

Another building which is to be enlarged is the present power house. A large direct current Bullock generator is to be installed to furnish power for the multiple voltage system of tool drive, developed by the Bullock Co., to be used throughout the shops. The power house is to be extended to a length of three hundred feet and width of sixty, the greater part of it being used for the winding and assembling of the electric apparatus. The foundry a most important factor in a well ordered plant, is a building two hundred feet long and one hundred feet wide. The pig iron is unloaded directly from the railroad to the charging floor. A cupola of large capacity, a core oven, travelling crane, etc., make the equipment complete. There is ample room for the extension of this building.

A blacksmith shop 100 ft. x 80 ft., with modern forges, steam hammers, and a pattern shop 200 ft. x 80 ft., completes the present plant; but it is expected that additions other than named above will be made in the near future.

A new and well appointed office building is to be erected in the spring to accomodate the Montreal Sales Organization as well as the works staff.

For several years the American Companies represented by the Allis-Chalmers-Bullock, Ltd., have been importing apparatus into Canada. In the West the mining and milling machinery of the Allis-Chalmers Co. are well known; while throughout Canada the machinery built by the Ingersoll Sergeant Drill Co. and the Lidgerwood Mfg. Co. are in general use.

Among the largest electrical units in Canada are those built by the Bullock Electric Mfg. Co. of Cincinnati. About three years ago their first large generator was installed in the Sheiks Island power house, near Cornwall. Its rating is 1000 K. W., 2200 volts, 3 phase, 60 cycles, 180 R. P. M., and in test was run at 60% over speed. Other large machines followed, such as the 1000 K. W. generator of the Canadian Electric Light Co. of Quebec. The voltage of this machine is 11,000, but it has operated most

satisfactorally. Recent installations have been a 750 K. W. for the St. Francis Hydraulic Co., a 1000 K. W. for the Sudbury Power Co., and an 800 K. W. for the Winnipeg Street Railway.

Turning to the field of induction motors, we find the two largest in Canada for H. P. per R. P. M., have been supplied by the Bullock Electric Mfg. Co., to operate the pumps supplying the City of Montreal. Reservoirs The rating of these motors is 400 H. P., 2200 volts, 3 phase, 60 cycles, 160 R. P. M., and in operation after a full load run of twenty-four hours, the rise in temperature was negligible. It is the intention of the Allis-Chalmers-Bullock, Ltd., to pay special attention to the development of the induction motors, both constant and variable speed, and its application to all classes of work.

Among the Electrical sights of Montreal is the substation of the Shawinigan Water and Power Co. The frequency of the incoming line is 30 cycle, while that of the Montreal system is 60 cycles. To change frequencies, five motor generator sets built by the Bullock Electric Mfg. Co. were installed, each generator having a capacity of 1065 K. W. at 2200 volts. The operation of these sets has been all that could be desired, and at times they have carriedan over load of 100%. At the present time. The Bullock Electric Mfg. Co., is building a monster frequency changer set for this station. The rating of the generator end is to be 5333 K. W., 2200 volt, 3 phase, 60 cycles, 300 R. P. M. For starting purposes a direct coupled induction motor is to be used.

An Allis-Chalmers-Bullock, Ltd, installation which is at present attracting a great deal of attention is the "Old Reliable" at the St. Louis Exposition. This set consists of a 3500 K. W., 6600 volts, 3 phase, 25 cycles, 77 R.P.M. Bullock generator driven by an Allis-Chalmers, horizontal, vertical, compound engine. The set has been called upon to perform very arduous service in the day time owing to the failing of some of the other sources of power, and at night supplies power for the beautiful and unsurpassed illuminations of the buildings and grounds.

Motor Equipment for Dominion Cotton Mills.

IN the Fall of 1898, while arranging the reconstruction of the Dominion Cotton Mills Co's. Hochelaga and St. Anns Mills, the question of renewal of power plant was taken up, and figures made to determine the most suitable arrangement for their purposes. There were three engines in operation in the Hochelaga mills, aggregating 1,700 H. P. One of which had been doing duty for 28 years, a drop cut off valve gear on the high pressure cylinder and a plain slide valve on the low pressure. Both cylinders had been re-bored till it was unsafe to repeat the operation without materially lowering the steam pressure. One battery of horizontal Tubular boilers was completely worn out, though the battery of Lancashire boilers was still in servicable condition for use at moderate pressures. As we propose to materially increase the production of the mills by rearranging the machinery, discarding obsolete and replacing with a modern machinery in a more compact and systematic lay out, a larger power plant would be required for which it was difficult to find space in a suitable location and a properly arranged steam plant would have involved tearing down buildings, moving boilers and engines, as well as closing of the mills at a time when many contracts were in hand and orders constantly increasing.

Careful estimates were made of the cost and operating expenses of a modern steam plant with rope drives to a central belt well from which the power was to be distributed mechanically. Figures were also made on a steam plant with mechanical drives for the central part of the mill while dynamos direct connected to the engines were to supply current for motors to drive the machinery in the more remote portions of the mill.

As, at that time, there were several companies controlling different, and more or less distant, water powers, who were transmitting electric power into the city, these were severally taken into consideration and the possibility of interruption of service, as well as cost of power compared with steam generated on the spot. It was a difficult matter to decide, there were so many good arguments pro and con. Finally a contract was made on 3,000 H.P. of electric current, with the Royal Electric Co. which, on account of limited service, made the price attractive to the Cotton Co., and the agreement was so drawn as to provide every possible safeguard and penalty against interruption of service. The limited service provided that power should not be used by the Cotton Co. during the six winter months between the hours of 4 and 7 P.M. so as not to lap onto the Electric Co.'s lighting load this making all this power available to sell again for lighting purposes.

The Cotton Company succeeded without difficulty in arranging with their help for a half hour earlier start and half hour noon so as to make a 54 hour week stopping at 4 P.M. in the winter, instead of the regular 56 hour week in the summer.

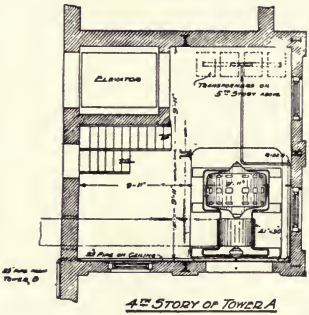
Electric Power being decided upon, careful tests were made to determine the power required in each department and a thoughtful study of the conditions to arrive at the best units to adopt, as well as, where to locate them.

As the load on a cotton mill is one of the most regular no advantage presented itself in individual drives for the machinery and a marked economy in the first cost and general higher efficiency was obtainable by grouping the machinery so as to admit of units ranging from 150 H.P. to 300 H.P., which were at the same time flexible enough to admit of any variation in the production desirable. The operation of a cotton mill resembles an endless chain in that the manipulation is continuous and un-interrupted from the opening of the bale of raw cotton to the finished fabric, each process depending upon the previous for material to go on with and a break or irregularity in any

department holds up the entire production. By giving each department a separate motor drive the failure to produce its share in the regular hours could be compensated for by running overtime, to make up for accidents or delays in any department, without the necessity of driving other departments with numerous machines unnecessary to the process which it might be desirable to increase.

The mill was large and the preparatory processes divided into two groups so it was deemed advisable to connect the power to the mills at two points central to the two sections into which power was transmitted, at the same time, shortening the lengths of the shafting required to distribute the power to machinery to be driven.

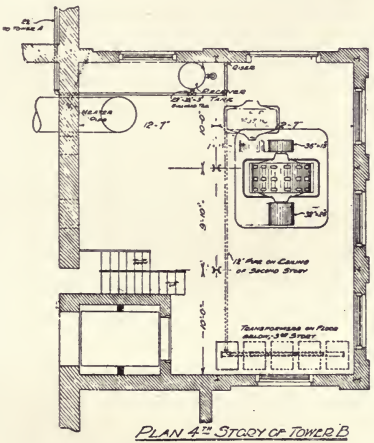
To admit of the utilization of the whole of the floor space within the mill for placing the machinery in regular and uninterrupted alleys, the novel idea of placing the motors in towers outside of the mill, adjacent and similar to the stair towers, was conceived. Besides the motors the towers provided room for the hot blast heaters,



Arrangement of Motors and Air Compressor in Electric Tower.

fans and main risers, as well as the elevator for each section of the mill, removing them from the interior of the mill where they formerly passed through from floor to floor, to a corner of the tower where they were enclosed in a brick shaft communicating with each floor by means of an automatic fire door.

As will be observed in the vertical section the tower floors were placed at an elevation sufficiently high above the mill floors so as to admit of belting from the motor pulley into each floor close to the ceiling with ample head room below the belts to avoid obstructing free passage and not interfere with the regularity of arrangement of the machinery. To avoid possible communication of fire from floor to floor through the belt opening, galvanised iron ducts enclosed the belts from where they



Arrangement of Motors and Air Compressor in Electric Tower.

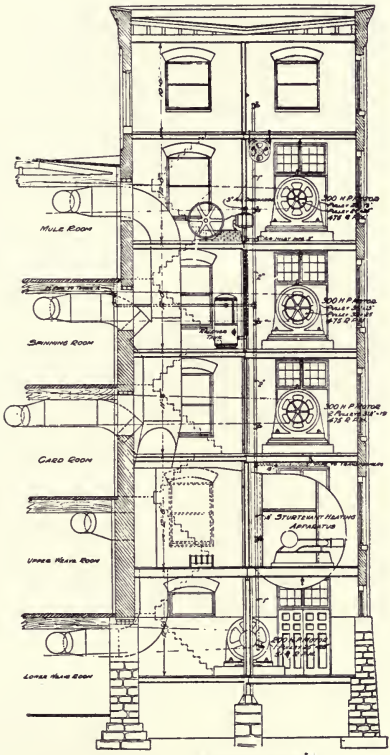
passed through wall into the mill taking in the large driven pulley the shaft passing through the casing at circular openings about one eighth of an inch larger than the shaft but not large enough to admit the cotton flying or dust being carried by the belt into the tower. Communication between the tower and mill was provided at each floor by means of small double doors, for passage through the wall an additional automatic sliding fire door being placed on the mill side of the wall.

The flights of iron stairs were arranged with landings at the level of the mill floors as well as at the level of the tower floors.

The weave rooms were located in the basement and first floor of the mill and the looms on both floors driven from the same shafts belting up and down. The motors were placed in the first floor of the towers. The 150 H. P. Motor in tower A drives into the middle of a main shaft in No. 1 mill about 200 feet long, tapering in size from the centre to the two ends. The 200 H. P. Motor in tower B drove into the middle of about 400 feet of shafting, driving the looms in No. 2 and 3 mill. Brick partitions divide the mills into sections, each about 200 feet in length. The wing, or No. 5 mill, was driven by a 50 H. P. motor inverted and the base secured to the ceiling of the lower weave-room, belting to shafts from pulleys on both ends of the motor shaft to the shafts driving the looms in the basement and first floor of No. 5 mill.

The cuts of cloth were transferred by two continuous belt conveyors running from the basement to near the ceiling of the first floor, passing through self-closing fire doors in the partitions on to the conveyor in No. 1 mill, near the ceiling, and, dumping on to a slide, shunting into the cloth room or bleachery in the No. 4 wing, at right angles to No. 1 mill.

Besides the large motor in the first floor of tower B, is located a duplicate set of motor driven triplex pumps for Drosphores for moistening the air in the mills. The tanks for supply and return water were located in the



Arrangement of Motors and Air Compressor in Electric Tower.

basement below the pumps, and here also was placed the automatic pump and tank receiver for the drips from the heaters instead of traps, returning the condensed water to the Lancashire boilers.

As the motor in the first floor of the towers drove two floors in the mills, this left the second floor of the towers available for placing the Sturtevant fans and heaters for supplying hot air to the mills. The corner of the towers, opposite the elevator well, being used for the large galvanized iron pipe risers of the heating system which connected through the brick wall into the mill at each floor, to the pipes distributing the heat for their respective sections, these connections, each provided with dampers permitted of regulating the temperature of the rooms as required independently of each other.

In the rearrangement the bale opening room was moved to the end of the new raw cotton stores but separated from the cells by brick walls, provided with automatic fire doors through which the bales are brought and put through the hoppers, whence the cotton is blown by a fan through pipes underground across the street and through the dust trunks into bins, a distance of 400 ft., and thence fed to the heaters and lappers. A 20 H. P. Induction motor cased in a glass partition near the ceiling of the bale opening room and ventilated by air from out of doors, drove the hopper feeders and cotton fan.

The laps were conveyed to the cards which were in two groups at different parts of the mill, one set working in one direction, the other, double in number, working in two directions, through the shubbing, roving and intermediates and then elevated to the third and fourth floors where were located the ring spinning frames and mule spinning respectively.

The warping, spooling and cone winding was done in the third floor.

What was formerly the No. 2 Boiler room altered into a slasher room, and driven by a 50 H. P. motor on the ceiling removing the accompanying steam, heat and odor from the mill. The former engine room was divided into

two floors and used for storage of warp beams, harness and loom parts.

The No. 1 Boilerhouse with Lancashire boilers was continued to furnish steam for the bleaching and finishing room and for heating also in the winter.

To return to the motor drives, the beaters and lappers, located in a building near the centre of the mill, were driven by a 150 H. P. Motor in a glass partitioned room in one corner of the lap storage space.

The No. 1 card room and preparatory machinery was driven from a three bearing, 300 H. P. Induction motor in the third floor of tower A. The cards etc., in No. 2 mill, as well as the shubbing, roving and intermediates in No. 3 mill (fed by cards in No. 5 mill) were driven from a 300 H. P. two bearing motor with pulleys on both ends of shaft and friction couplings provided at the head ends of line shafts in the mills to add flexibility of control.

The cards in No. 5 were driven by a 75 H. P. motor inverted on the ceiling and belted from pulleys on both ends of the shaft. Any one familiar with card rooms will appreciate the conditions under which this motor had to operate, nevertheless the motor worked satisfactorily with frequent blowing with jet to remove cotton fluff by means of an air hose connected with the piping leading to the motor driven air compressor located on the fourth floor of tower B.

In the fourth floor of tower A, a 200 H.P. motor drove the ring spinning frames in No. 1 mill, and in tower B. a 300 H.P. motor drove the ring spinning, warping and spooling in Nos. 2, 3 and 5 mills.

The motor in the fifth floor of tower A was of 150 H.P. capacity, which drove the mule spinning in the fourth floor of No. 1 mill.

The motor in the 5th floor of tower B was of 300 H.P. capacity with two bearings and pulleys on each end of the shaft from which belts passed through the wall into the mill driving the main line shafts for Nos. 2, 3 and 5 mule rooms.

Our experience with mule spinning shows it advisable

to group as many mules together as convenient, as in running a few mules the fluctuation in power is extreme and this difficulty is, to a large extent, overcome when driving a greater number of machines owing to the better average and more uniform demand for power.

The 6th floor of the two motor towers is occupied by switchboards controlling the various lighting and power circuits, the most of which are centralized in the two towers, which are connected by two independent 2 phase. 2,000 volt circuits reaching the mill by independent routes so that in case of fire or accident which might damage either of the transmission lines the other could be made to carry the load until such time as the other could be repaired. A separate terminal pole serves each of the towers, about 100 ft. in height and has mounted upon it a railed platform above which are placed cabinets for each circuit containing lighting arrestors and 4 Pole Shutter switch to permit of getting at the circuits at the pole in case of fire in the mill or accident to the switchboard necessitated opening the circuit outside of the mill.

Besides the double circuit connections from the Supply Co.'s lines to each of the towers, the towers are interconnected by a bridge circuit controlled by a double throw switch in each tower connecting to the feeders going into either tower.

Lighting transformers and transformers for 500 Volt Motors at which pressure all motors of 50 H. P. or less are operated are located on the fourth floor of each tower. A spare transformer is placed in each bank and a break down switch provided which permits of alterning the connection of this spare transformer so as to couple the 5 secondaries in multiple when utilized for lighting or connected to in series when required for motor power.

Summary—All that could reasonably be expected in the way of flexibility, centralization of control, reduction of attendance, and minimizing of stoppages together with ability to make up for delays by running any desired section ; overtime was accomplished.

In the main buildings due to the electric drives and

improved machinery, nearly 40% increase in production was obtained.

The electric Motor equipment saved the construction of a new power plant, and additional space and buildings to cover the boilers and engines. The space occupied by the motors was not so much as would be required for the belt wheel of a steam drive, and the towers, wherein, the bulk of the motors were located was outside the main mill on ground, otherwise, useless instead of using valuable space in the mill which was, therefore, used to place additional machinery.

Considering the interest and depreciation on a steam plant, the cost of the rental electric power was no more than steam would have cost, and what would have been a very large investment for power plant and buildings was very materially reduced.

An idea of the compactness of the motor plant is illustrated by the following extract from a letter from one of the men installing the motors to his friend in Pittsburgh. "They just built two big chimneys back of the mills and stuck all the motors into them."

The Locomotive and Machine Company of Montreal, Limited.

AT Longue Pointe on the North Shore of the St. Lawrence River, about five miles in an easterly direction from the centre of the City of Montreal, are situated the works and property of the Locomotive and Machine Company of Montreal, Limited. The Company's property embraces 70 acres of land, and the location is an ideal one for manufacturing purposes. At present, communication with the City is afforded by the lines of the Montreal Terminal Railway, and of the Montreal Street Railway Company. In a short time there will also be connection by water, as a dock is in course of

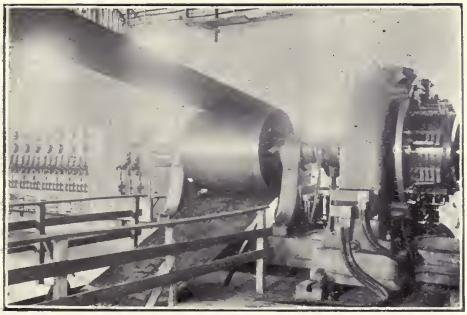
Shops of the Locomotive and Machine Co. in course of Erection.

construction at which even the largest Ocean Steamers may discharge or take on cargo. Visitors can reach the works by the Notre Dame or St. Catherine Street Cars, or by those of the Montreal Terminal Railway.

The Capital stock of the Company is $3,000,000. Their shops occupy a floor space of nearly 250,000 square feet and are used solely for the purposes of building Locomotives and fabricating Structural Steel. As now

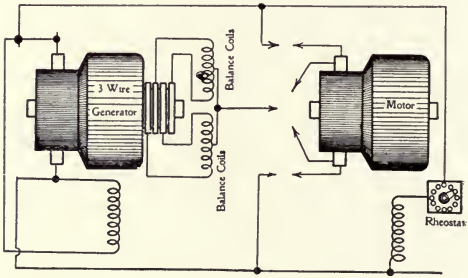
equipped, the shops have a capacity of 250 Locomotives per year, and their annual output of Structual Steel is 12,000 tons. At present their employees number 1000.

In the opinion of experts the arrangement and equipment of the Company's shops are superior to those of any other like industry to be found on either continent The Buildings are of a very substantial character and have all been erected with an eye to future extensions. They contain the most modern tools and labor-saving devices, but, as it is principally because of their Electrical Equipment that they stand unique a short description of the latter may prove interesting.



In the Company's Power House two generators are installed; one is an Engine-driven machine with provision for a motor connection if such should be desired; the other generator is Motor-driven. Power for the latter is supplied from Shawinigan Falls, 90 miles distant. Both generators were manufactured by the Western Electric Company, and from them continuous or direct; current is obtained at 115 and 230 volts. The Engine-Driven Machine is a Three-Wire or Double-Current Generator, but, its alternating current feature is only used for the pur-

pose of securing current at 115 volts by means of the "Balance Coils" which are connected to the Slip Rings on the armature of the Generator. Below is a diagrammatic sketch showing the Three wire Generator with its Commutator Collector Rings and Balance Coils, as well as a Motor which, while having its field coils connected across the circuit from the Generator's comutator, may have its armature connected to these same terminals, or to one of them, and to the terminal coming from the centre of the Balance Coils; by this means 115 or 230 volts may be applied to a motor armature and two speeds obtained. Intermediate speeds and speeds in excess of the normal speed at 230 volts are secured by introducing resistance into the motor's field circuit.



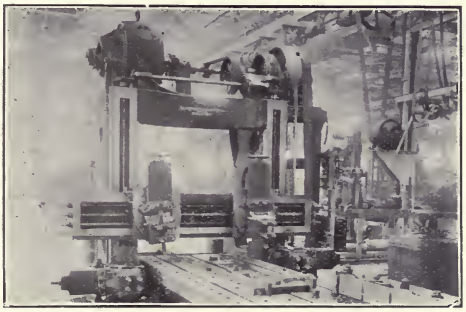
Three-Wire or Double-Current Generator and Circuits therefrom.

This system of varying the speed of motors has been developed under the supervision of Mr. N. W. Storer of the Westinghouse Company at Pittsburg, and it is called the Storer system.

For a number of years, two Generators in series, as well as Rotary Converters, have supplied energy to Edison Three-Wire Circuits, but the use of a single Generator uch as that above described for this purpose is a more novel arrangement, and its simplicity and smoothness of

operation commends it in an especial manner whenever two voltages are required for any purpose. When it is desired to obtain alternating current from a Three-Wire Generator, the "Balance Coils" are generally replaced by Transformers the Secondary coils of which may be for any designed voltage required.

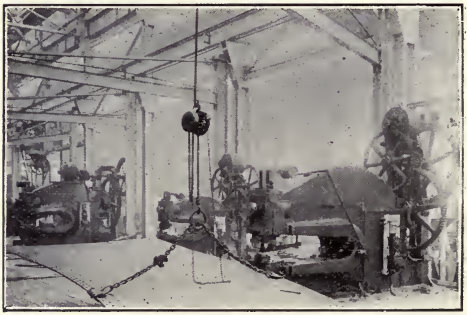
Simple Three-Wire Circuits are run throughout all the shops of the Locomotive and Machine Company. The Lighting, both Arc and Incandescent, is done at 115 volts; the constant Speed Motors are operated at 230 volts, and the Variable-Speed Motors are connected by means of their Controllers to the 115 or the 230 volt circuits as required.



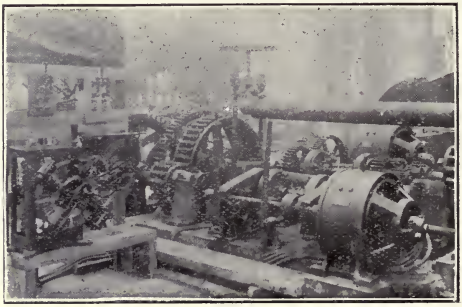
When a change of Tool-Speed is desired, there is no changing of gears or shifting of belts—a simple movement of the Controller Handle is all that is necessary, and the result is such a saving of time and energy on the part of the Tool Operator that the Shop's output is limited only by the capacity of the Tools. The shops of the Locomotive and Machine Company continuously afford practical proof of this statement.

With the exception of the Crane Motors which were supplied by the Canadian General Electric Company; all

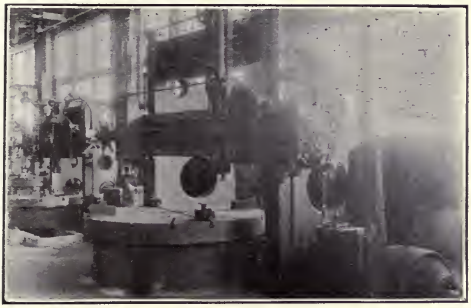
the Motors in these shops together with their switches, starting rheostats, controllers, etc., were supplied by the Westinghouse Electric and Manufacturing Company. The



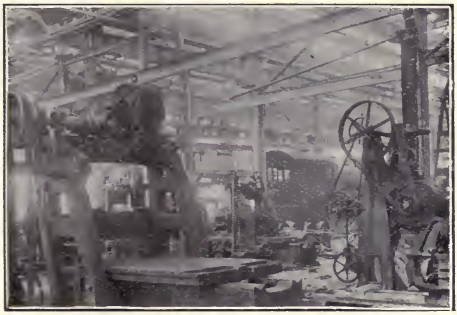
Controllers in use on the Variable-Speed Motors enable the Tool operators to obtain a speed range of 4 to 1. There are fifteen steps or notches on the Controllers for different speeds in one direction and six notches in the



reverse direction. The speed changes are made in nearly equal increments throughout the whole range ; Tools that may require a greater speed range then 4 to 1 are equipped with gears or cone pulleys.

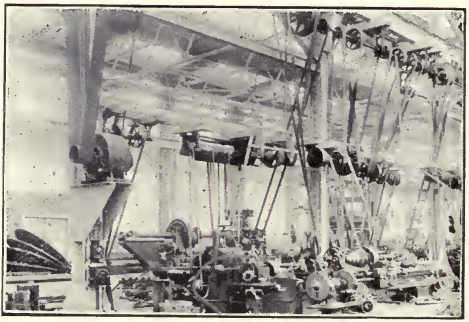


The chief feature in a Motor-Driven Shop is that the Tools may be constantly worked to their utmost capacity, and the productiveness of such a Plant is in many in-



stances a revelation to those accustomed to old style equipments.

Another important feature is the power saved by the elimination of shafting. Then there is the addition to the Clear-Head Room space and the greatly improved Lighting. The latter results are well exemplified by the accompanying illustration



At the present time, the Locomotive and Machine Company have in use Motors to the number of 140 in sizes varying from the 3-H.P. machines on some small shapers to the 60-H.P. motor driving the blower in the Foundry. There are shunt, series and compound-wound motors in this equipment. Groups of small tools are driven by shunt motors as are also constant speed tools ; Tools that may be started with a load on them are driven by compound-wound motors. The Cranes are supplied with Railway Type Series motors. The Plate Bending and Straightening Rolls are driven by compound-wound machines, the series coils of which have been made unusually strong in order to enable the motors to perform the work which is required of them. Series Motors have been usually placed to drive Rolls, but this practice necessitates constant attention on the part of an attendant, in order to prevent

accidents from occuring immediately after the plates go through the Rolls. On the other hand, the shunt winding on the Compound Motor prevents overspeeding, and does away with the special attendant.

All the Shunt-wound Motors in these shops have been designed to operate satisfactorily when their speed is increased 40 per cent by field weakening, and they are provided with rheostats for this purpose. In the event of further developments in the production of high-speed—tool-steel, the advantage of being able to speed up the constant speed motors without having to resort to a change of pulleys is one of their most valuable features,

The Locomotive and Machine Company's shops are driven by electricity, and they were built by electricity. A temporary shop was erected near the site of the present Shops and in it were set-up Punches, Shears, Air-compressors, Cold Saws, Rotary Planer, Rivet and Bolt Makers, Pneumatic Reamers, and Riveters ; in fact a large part of the Structural Steel Plant which has since been permanently installed in the Structural Steel Shop—and in this modest structure the entire frame work of all the shops was fabricated. Induction Motors supplied with current from Shawinigan Falls were the source of energy

for all these tools. A double-commutator Western Electric, 115–230 volt Generator was also set up in the temporary shop; it supplied current for lighting the grounds, and for the cranes which were set upon their tracks before the buildings were roofed. The Cranes were thus enabled to materially assist in the work of unloading cars and setting up tools, etc., long before the Power House was ready for operation. This Generator coupled to an induction motor now forms part of the Power House Equipment.

Any person interested in the construction of Locomotives, the fabrication of Structural Steel, or in electrically-driven Machine Tools, will be well repaid by a visit to the Works of the Locomotive and Machine Company, whose officers and management are at all times most courteous in affording opportunities to inspect their Shops.

Montreal Street Railway Company.

GLANCING over the system to-day with everything in working order, it is scarcely possible to conceive the revolution effected nor the enormous increase in transportation since the first electric car was run in September, 1892. The Montreal Street Railway Company was one of the first Companies on this Continent to change mode of transportation from horse-power to electric traction. For the year ending September 30th, 1892, the receipts of the Company were $564,406 while for the year ending September 30th, 1903 they reached $2,-222,787. The total number of paying passengers carried during the year ending September 30th, 1892, was 11,-631.386 as compared with 54,592,014 for year ending September, 1903. The transfer passengers for year 1892 was nil as compared with 16,774,595 in 1903; a total of 11,631,386 for year ending September 30th, 1892 as compared with 71,366,609 for year ending September 30th, 1903.

A Horse Car.

The old method of travel was by horse cars running on light tracks in the Summer, by sleighs in Winter, and by cumbersome busses in the Spring, until the thaw admitted the use of the track. All this, however, is a thing of the past, and travel instead of being irksome and uncomfortable is now a convenience and a pleasure. In our most severe weather we are often reminded of this fact by hearing passengers remark as to the difference at present

General Office Building.

in the comfortable and warm cars as compared with the days when the system of heating was by covering the floor of the sleighs with straw after the manner used for "bedding horses and cattle."

The Executive or General Offices of the Company are situated in the Company's own Building, a handsome six storey structure at the corner of Craig street and Place d'Armes.

The various Mechanical and Electrical departments may be visited and studied with advantage ; those devoted to Science will find much with which they are familiar, and possibly much that is novel and instructive.

The difficulties which presented themselves to the Company at the introduction of the present System were, the severity of the grades on many of the streets, and the depth of the snowfall. An idea of the grades of many of the streets may be obtained from the following : Amherst street rises fifty feet in a distance of eight hundred feet, with a maximum grade of ten-per-cent for about one hundred and fifty feet. St. Denis street rises forty-seven feet in a distance of seven hundred feet, with a maximum grade of eight per-cent for about three hundred and fifty feet. St. Lawrence street rises sixty-eight feet in a distance of fifteen hundred feet, with a maximum grade of eight per-cent for about one hundred and fifty feet. Beaver Hall hill on which there is a reverse curve half-way up rises sixty feet in a distance of nine hundred feet with a maximum grade of eleven per-cent for about seventy-five feet. Windsor has a rise of seventy feet in a distance of fifteen hundred feet, with a maximum grade of ten per cent for about two hundred feet. On Guy street and Cote de Neiges hill there is a rise of three hundred and fifty feet, in a distance of five thousand one hundred and fifty feet, with a maximum grade of eleven per-cent for about one hundred feet. St. Lambert's hill and Place D'Armes hill short grades of eleven per-cent.

An idea of the vast amount of labor entailed and the enormous expenditure in connection with snow storms and Winter expenses may be gathered from the fact that

the average snowfall for the last twenty Winters is about 120 inches per annum. The company takes no chances with Winter storms; a keen weather eye is kept both on the "Probs" and on the local weather manifestations, and the moment trouble is sniffed, the enemy is tackled. Any symptom of a heavy snowfall, let alone a storm or a blizzard, calls out the electric sweepers and plows, with the result that it has been demonstrated that a car service can be operated at all seasons of the year, and it is correct to say that the Winter street car service in Montreal has fewer interruptions than in the Northern Cities in the neighboring States, for the simple reason, that not so often subject to attack and fearing danger less, the American Companies are less effectively equipped. Fighting the climatic conditions is a matter of money, of course, as well as brains. Apart from the snow fighting equipment necessary which consists of twenty-four electric sweepers and two Rotary plows, the mere cost of the removal of snow is a large item. The cost to the Company on this account during last Winter amounted to well over $200,000 equal to about ten per-cent of the gross earnings or about two and a quarter per-cent on its Capital, and necessitating the employing of about one thousand extra men.

The Montreal Street Railway Company is regarded as one of the most flourishing corporations on the Continent. Its Capital consists of two million five hundred thousand dollars of bonds and six million five hundred thousand dollars of Common Stock (all paid up) on which latter ten per-cent per annum is paid quarterly.

The system is quite an extensive one, the Company at present operating about one hundred and twenty miles of track, also forty miles of track of the Montreal Park and Island Railway Company, which is controlled and operated by the Montreal Street Railway Company. Additions are constantly being made, and during the present season it is expected that about 10 miles of track will be added to the system.

Some of the streets are paved with stone, others with wooden blocks, and a number with asphalt.

The rails which have been adopted by the Company as standard are now being used both in new work, and renewals of track are of the grooved girder type, weighing ninety-six pounds to the yard, and also eighty pound "T" rails, and in lengths of sixty feet. Splendid specimens of track work may be seen at the intersection of St. James and McGill streets, Windsor and St. Catherine streets, and Victoria square, etc.

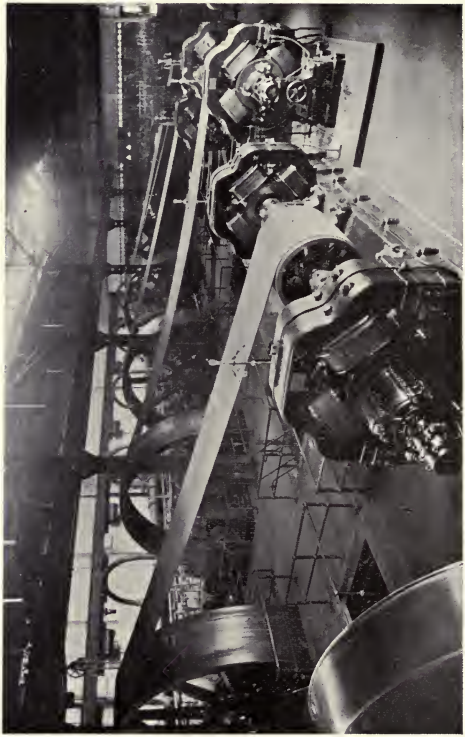
The overhead construction is of the standard type, iron poles being used in many of the principal streets, at an average distance of about one hundred feet. The trolley wire throughout the city is No. 00, and on the suburban lines in No. 0000. The feeders of which there are about one hundred and seven miles, are No. 0000 wire, 250,000 and 500,000 C. M. insulated cables.

Outside of Power House.

The Power House is situated on William and Barre streets. The frontage of the property is three hundred and ninety four feet, with a depth of two hundred and thirty-five feet. The Power House building is divided into four sections: one section being used for the engines with dynamos in connection with same, one section for machinery used in connection with the water power received, and two sections for boilers.

The section used for engines and dynamos is two hundred and thirty-five feet long by eighty feet wide, and contains six Corliss Compound Condensing Engines of six hundred and fifty horse-power each: one Corliss Compound Condensing Engine three thousand four hundred horse-power: one Corliss Compound Condensing Engine sixteen hundred horse-power, all manufactured by the Laurie Engine Company, Montreal, also one Corliss Compound Condensing Engine, sixteen hundred horse-power, manufactured by the Pennsylvania Iron Company of Philadelphia. Each engine is provided with two governors, one of the "Porter" type, capable of controlling the speed within two per cent. of the normal rate, and a governor having an automatic valve, which shuts off the steam when the engine reaches ten per cent. above the normal, so that should the ordinary governor become defective, damage is quickly prevented. The engines are carried on steel beams, on foundations of solid stone and cement, carried down about eight feet below the street level. The dynamos in connection with the six hundred and fifty horse-power engines run the length of the building opposite the engines, and are belted to same, four 200 K. W. machines to each engine. The dynamos in connection with the three thousand four hundred, and sixteen hundred horse-power engines are direct connected and consist of one 1,500 K.W. generator, manufactured by the General Electric Company, and two 800 K. W. generators, manufactured by the Canadian General Electric Company.

There are 10 No. 80 Edison generators of 200 K. W. each, and six Multipolar generators of 300 K. W. each,



manufactured by the Canadian General Electric Company.

The leads from the generators to the switchboard are connected along the basement on racks with porcelain insulators. The engine room is provided with two travelling overhead cranes of ten tons capacity each. The room presents a striking appearance at night when illuminated with over three hundred incandescent lamps.

The most interesting feature of this department, however, remains to be seen in the switchboard, which was built by the Company, and is one of the finest switchboards on the continent. Here all the vast machinery with its great power is under absolute control. With a touch of the hand the mysterous power is sent on its way to perform its Herculean feats, and with the same ease its influence is rendered negative. There are many delicate instruments displayed here, the value of which is only intelligible to the scientific mind.

The board is constructed of polished blue Vermont marble, 90 feet long and 12 feet high, reached by a marble stairway, terminating in a gallery laid with vitrified tiles running the complete length, and protected by a polished brass railing. Along the top is a row of fifty incandescent lamps, one over the instruments of each circuit.

Passing to the reverse side of the "board" an entirely different picture is presented; here there is a complete maize of cables connected with the instruments, and each having a numbered label. The feeders pass out of the building through a special tower, and are thence distributed in their several directions. Passing through a door-way on the south side of this section, or Power House proper, we enter the building containing the water power plant. The erection of this building, and equipping the same with the necessary machinery, was found necessary on account of additional power being required. The current is received into the station from the Montreal Light, Heat and Power Company, by which a continuous 5,000 horse-power direct current is received from their generating plant at Chambly, seventeen miles from Montreal.

This building is ninety feet long and forty feet wide, and contains the following machinery for receiving and converting the power received :—Six direct connected induction motor generator sets, each having a rated capacity at the direct current end of 500 K. W. Two of these units were built by the Westinghouse Electric and Manufacturing Company, and four by the Canadian General Electric Company. The units are started from the direct current side only. They are brought up to speed using the direct current generator as a motor, and when at approximately normal speed, as indicated by the position of the field rheostat, the induction motor is connected to the alternating current circuit. By a change of connections and adjustment of the generator field, the unit is then made to take its share of the load. The switchboard for the control of these units is of blue marble, 26 feet long and 8 feet high, and has a gallery with brass hand rails and tile flooring similar to the switchboard in Main Power House.

The building is provided with an overhead crane of 20 tons capacity.

At the north side of the Power House proper and adjoining the same is the Boiler house, which is divided into two sections, one section contains a group of sixteen Lancashire boilers of two hundred and fifty horse-power each, made by Daniel Adamson & Co., Dunkinfield, England, arranged in two batteries, each boiler is fitted with a dead load safety valve, a six inch steam nozzle, a combined low water alarm and safety valve, and a Government pop valve on the cover of the manhole. At a temperature of about four hundred and fifty degrees the gases pass into a Green economizer which heats the feed water at a temperature of about two hundred and fifty degrees. The second section of the boiler house contains a battery of Six Babcock & Wilcox water tube boilers of two hundred and fifty horse-power each, also a battery of six Lancashire boilers of 300 horse-power each, built by the Caledonia Iron Works Company of this City. All of these boilers are fitted and equipped in the same manner

as the Lancashire boilers, previously described. The boilers are fed by six Northey pumps through duplicate pipes. There are two chimneys, one of which is the highest in the City, the core is circular with an inside diameter of twelve feet, and rises to a height of two hundred and fifty-six feet above the fire grate. With a view to obviating danger from fire the buildings have all been made practically fireproof with Granolithic or cement doors, etc.

The Mechanical, Wood Working and Electrical shops of the Company as well as the Stores department is situated at the corner of St. Catherine and Harbor streets in the East end of the City. These shops are solid brick buildings on stone foundations and cover an area of 77,000 feet. In the Carpenter, or Wood working shop, which also embraces the Paint shop, cars requiring to be overhauled or repaired are attended to, and all new cars required are built. The Company, ever on the alert to be up-to-date and provide for the comfort of its patrons, commenced some years ago building larger cars: These cars have two trucks and are equipped with four forty horse-power motors each, improvements are added from time to time, among which may be mentioned the large cars of the Park & Island Railway Company built at Montreal Street Railway shops. These cars are fitted with chair seats, air-brakes, electric bells, etc. The latest improvement in cars, are those which are now being built, some of them are actually in commission. They are fitted with seats both cross and longitudinal, air-breaks, electric bell, electric heaters, enlarged platforms back and front, and are so constructed that the windows can be closed or opened, and may be used for either Summer or Winter service, without change, instead of having to transfer the trucks from open car bodies to closed car bodies and vice-versa, entailing considerable expense to the Company.

The Company is also, at present, transforming some of their present open cars so that by simply putting on one side and changing the location of the seats, which

can be done in a very short time, they can be changed to closed cars, this will also do away with the expense and labor in transferring trucks. In addition to the Carpenter shop there is also the Machine shop and Blacksmith shop fitted with all the necessary machinery and plant for supplying the requirements of all departments. Here is also situated the Brass Foundry in which all brass and copper castings required are made. Immediately above the Machine shop is the Winding room fitted with all the necessary machinery where all the electrical repairs are attended to.

The rolling stock of the Company consists of nearly eight hundred cars, including sweepers and plows, the whole of which, but with few exceptions have been built by the Company. The car stations of the Company are situated at St. Henry, in the West End of the city, Hochelaga in the East End, St. Denis Boulevard in the North End, and Coté street in the Center of the city. All of these buildings (with the exception of Coté street, which was formerly used as a horse stable) have all modern improvements; are heated by Sturtevant Hot Air System, are of solid stone foundations with iron girder roofs.

There are also car storage sheds situated at St. Denis Boulevard and St. Henry for storing open cars and closed cars out of service.

Electrical Development of Ottawa City and Vicinity.

OTTAWA, the capital city, with its 60,000 happy and progressive inhabitants, occupies an advantageous position at the junction of the great river bearing its name, with the Gatineau and Rideau rivers. These streams flowing from the West, North and South respectively, drain an immense territory. They contain many falls and rapids and Ottawa stands in the centre of a region remarkable for the wealth of its water powers. It has been estimated that within a radius of about fifty miles from this city may be found water

View of Ottawa Post Office.

powers aggregating 500,000 H.P. at low water. Many of the falls are of great size and while few of these powers have been utilized for the operation of machinery, their development, in the majority of cases, could be effected without serious engineering difficulties and at moderate cost.

One of the principal falls within this region is that known as the "Chaudière Falls" where the Ottawa river drops some 40 feet. Its situation at the very door of the city has made of Ottawa, and its sister city of Hull across the river, a centre of electrical activity. Two miles above the city are the "Little Chaudière" rapids where nearly 20,000 H.P could be obtained under a head

of 10 feet. A few miles above this are the "Deschênes" rapids of equal power and head now partially developed. Thirty miles up stream are the "Chats Falls" where the river drops 40 feet and 75,000 H. P. could be developed under favorable engineering conditions. At "Portage du Fort", 50 miles from the city 25,000 H. P. could be obtained under 15 feet head. A little higher up the river at Calumet Island are the "Mountain Chute" and

"Grand Calumet Falls", the first a drop of 20 feet and the latter 56 feet. On the other side of the island, the west channel, is a succession of rapids forming a fall of 70 feet. At "High Falls", 56 miles from Ottawa on the Coulogne river, a tributary of the Ottawa, a fall of 138 feet is estimated at 11,000 H. P., and at a distance of 60 miles "High Falls" on the Black river, another tributary, 6,000 H. P. could be obtained under a head of 120 feet.

On the Gatineau river the following powers are available :—5 miles from Ottawa "Farmers Rapids", 20 ft. high, 8,000 H. P. ; 6 miles away "Chelsea Falls", 39 ft. head, 15,000 H. P. ; 7 miles away "Eaton's Chute", 20 ft. head, 8,000 H. P. ; 14 miles away "Cascades", 12 ft. head, 5,700 H. P. ; 18 miles away, 4,000 H. P. under 10 ft. head ; 30 miles away "Paugan Falls", 60 ft. head, 24,000 H. P. Thus on this river within 30 miles of the city, approximately 65,000 H. P. could be obtained at low water.

On the "Lièvre" river, emptying into the Ottawa 20 miles below the city, an almost equal amount of power could be developed in 30 miles. The principal falls known as "High Fall", 28 miles from Ottawa in an air line, could alone furnish 32,000 H. P. under a head of 180 ft.

There are also many smaller water powers on tributaries of the rivers named.

The estimates are based on the natural flow of the different streams at low water and represent the power which would be available on the shafts of turbines having an efficiency of 80 per cent.

All these rivers are enormously increased in volume during spring freshets and many of the powers could be much improved by storing the water during seasons of flood and allowing it to escape so as to increase the flow during periods of low water.

At Ottawa, it will be found that water is used somewhat wastefully. The present developments are the result of individual efforts rather than concerted action. Some years ago the owners of saw mills who were practically

the only users of water for power, built in partnership the present low timber dam which stretches across the river just above the falls, but beyond this no systematic development has taken place. While much power is used, much more could be secured by a scientific rearrangement of the works at Ottawa, and specially by some system of water storage in the upper reaches of the river which contain many and extensive natural reservoirs. At the present time the Dominion Government is sending out Engineering parties with a view of ascertaining the possibilities in the matter of water storage.

There is nothing particularly original here in the manner of using water ; some of the users take their supply in the open stream above the dam, others draw water through square timber flumes 15 to 20 feet square and varying in length up to about 200 feet. These flumes terminate in artifical ponds built of timber, hewn out of the rock, or walled in with concrete, where the water is allowed to reduce its speed before entering the gratings leading to the turbines. With the exception of one or two plants, where vertical submerged turbines are used, all the works are operated by horizontal turbines, also submerged in large box flumes or penstocks and discharging into steel draft tubes. From these the water is lead to the river below the falls through open canals cut in rock or through natural channels between islands which form part of the city. The working heads vary from 20 to 35 feet.

THE OTTAWA ELECTRIC COMPANY.

Among the undertakings for the generation of electricity for light and power The Ottawa Electric Co. may be considered the oldest because it represents a consolidation of three pioneer companies ; The Ottawa Electric Light Co. established in 1881 for lighting the city streets by means of arc lamps. The Chaudière Electric Light & Power Co. which introduced incandescent lighting in 1886 and The Standard Electric Company of Ottawa, Ltd. which entered the same field in 1891.

This consolidation took place in 1894. In the year 1900 Ottawa was visited by a devasting conflagration which destroyed the greater part of the united works. This naturally led to a complete reconstruction of the generating plant on modern and efficient lines. Some idea of the success and growth of this undertaking may be obtained from its records which show that when the company was organized in 1894 the installation consisted of :—

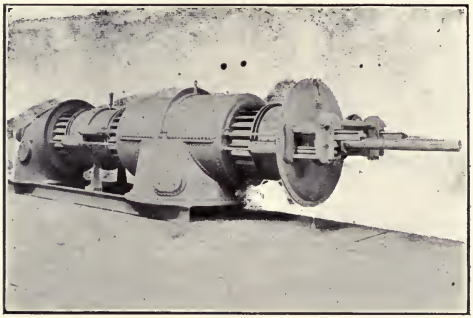
		In 1904 we find :	
Incandescent lights,	42,152	Incandescent lights,	126,657
Arc lights.....	440	Arc lights.....	986
Motors.....	68	Motors.....	186
No. of Customers...	2,720	No. of Customers...	6,757

a result which must be deemed remarkable considering the population of the city.

The generating works consist of a Central Station operated by water and two auxiliary stations, one of which is operated by steam and used only when water power is much reduced through "ice troubles" in winter, or other causes.

The Central Station is a brick building 150 x 45 ft. with steel framework and cinder concrete roof waterproofed, built on foundations of concrete laid on solid rock about 18 ft. below the street level. The walls enclosing the water intake, the flumes and penstocks are built of concrete reinforced by steel framework imbedded in the walls. There are three generating units of 1,000 H. P. each with provision for a fourth unit. They are Westinghouse two-phase A. C. generators running at 180 r. p. m. and giving 2,300 volts at 60 cycles. These are directly connected to turbine sets, each consisting of three 39 in. wheels of Stillwell-Bierce manufacture, (Dayton, Ohio) mounted on the same horizontal shaft and discharging into a tail race, partly under the building and parallel to it, through two steel draft tubes, one being common to two wheels. At the lower end of the building the tail race, about 30 ft. wide and covered by a concrete arch on which the building rests in part, becomes an open channel emptying into the river 100 ft. away.

The water is taken at the upper end of the building and is led into a large covered concrete flume parallel to and lying outside the building. From this flume water is admitted through lateral openings into concrete square penstocks, one for each set of turbines which are submerged therein. The working head is 25 to 28 feet.



A Turbine Unit.

Two exciters, either capable of exciting all the generators, are also directly connected to independent turbines in separate penstocks.

The generators mentioned supply current directly for incandescent lighting and for power to induction motors. Direct current power at 500 volts is supplied through a Westinghouse Rotary Converter of 300 K. W. and the street arc lamps, (D. C. enclosed type) are operated by current from 6 Western Electric Co. multicircuit arc generators driven in pairs by direct coupling to 3 Westinghouse 2 phase induction motors of 250 H. P. each.

All the distribution is controlled from this central station. Current from the generators in the auxiliary stations is carried to this station, all generators being paralleled. The distributing switchboards are in this

station. Oil switches are used exclusively. The arrangement is somewhat novel; all switches and station transformers being placed high up on the walls of the station. The switches being connected to the operating handles on the switchboard panels by cranks and rods. This arrangement in connection with a fireproof building and fireproofed cables reduces to a minimum liability of damage from electrical troubles.

The speed of the waterwheels is controlled by Lombard governors.

The hydraulic auxiliary station, a substantial stone building is equipped with two Westinghouse A. C. generators of 1,000 H. P. 2 phase 60 cycles, running at 327 r. p. m. and belted to jack shafts which are driven, through crown, wheel and pinion gearing, by vertical turbines of canadian manufacture known as the "New American."

The steam auxiliary station has a capacity of about 1,000 H. P. Westinghouse generators belted to Wheelock tandem-compound condensing engines.

The services of this company not only cover the city, but extend into all adjoining suburbs and throughout the neighbouring city of Hull.

THE OTTAWA ELECTRIC RAILWAY COMPANY.

This company which has had a most successful career and has served as a model for other electric railway undertakings throughout Canada was organized in 1891. In July of that year it started operations with 14 cars—shortly after, it absorbed The Ottawa Street Railway Co., the old horse car line, and electrified it.

It is worthy of note that this was the first company to attempt running cars throughout a canadian winter. It succeeded in overcoming all difficulties and established a basis for successful winter operation, notwithstanding predictions of failure from many wiseacres.

The progressive policy of this company in establishing parks and pleasure grounds out of town, notably Roke-

cliffe Park and Britannia-on-the-Bay, has made of Ottawa, always a favoured city, a place most pleasant to live in.

The progress of this enterprise has been very rapid; To-day it has 41 miles of track reaching from the centre of the city, 4.41 miles in one direction and 7.28 miles in another. It has in regular use 105 motor cars and 6 trailers. Westinghouse equipments are used throughout, motors ranging from 30 to 50 H. P.

The road is double track with "T" rails varying in weight from 56 to 80 lbs. per yard, the heavy rails laid in 60 ft. lengths on heavy cross ties with "continuous" rail joints make an ideal roadbed.

The generating equipment consists of a single unit of 1200 K. W., a Westinghouse D. C. generator running at 600 volts, supplemented by a storage battery of 268 chloride cells of a capacity of 1,000 ampere hours, with booster, floating on the system. The generator is direct-connected to six 54 in. wheels of Stillwell-Bierce manufacture mounted on one horizontal shaft, all being submerged in a large box flume made of concrete reinforced with steel frame into which water is drawn directly from an arm of the Ottawa river which is dammed at this point. The discharge through 3 steel draft tubes, is carried through an open canal at right angles to the station building, into the stream just below the dam. The head is 20 feet.

A motor-generator unit of 1,000 K. W., the motor being a 2-phase A. C. induction motor, permits in case of need of obtaining power from any of the several A. C. generating stations in the vicinity.

The park at Britannia-on-the-Bay is the chief pleasure resort about Ottawa. Grounds have been laid out beautifully. A pier over 1,000 feet long extends into Lake Deschenes and the place is a favorite with all classes for boating, bathing, etc.

During the past year the cars of the company carried 8,000,000 passengers.

THE HULL ELECTRIC COMPANY.

About 1893 this company was chartered to build a tramway through the City of Hull and for nine miles out to the pretty village of Aylmer on the north, or Quebec side of the river above Ottawa, and also to supply light and power in Hull and Aylmer. The company showed a progressive spirit and gradually improved its property and extended its lines. At this time it operates 10 miles of double and 6½ miles of single track with 17 motor cars, 4 trailers and 2 electric locomotives. Large and commodious cars run from Ottawa near the Post Office across the famous Interprovincial bridge, through Hull to "Deschenes" and past the Golf Links, Aylmer, on to Victoria Hotel—all popular summer resorts—and to Queens Park, at attractive place of amusement owned by the company, on the north shore of Lake Deschenes and close by "The Victoria Yacht Club." Canadian General Electric Co.'s equipments are used on the cars.

The generating station is situated on the north bank of the Ottawa River at Deschenes Village. It is a wooden structure, metal covered and metal roofed containing the following electrical equipment :—2 Canadian General 350 K.W. D.C. 600 volts, multipolar railway generators which carry a load varying between 200 and 500 K. W. 2 Canadian General A. C. monocyclic generators, 2,300 volts, 60 cycles, used for the supply of light and power in Hull, Aylmer and Deschenes. All machines are belted to horizontal shafts driven, through crown wheel and pinion gearing, by vertical turbines submerged in timber box flumes.

Lake Deschenes, an expansion of the river Ottawa, forming a large body of water several miles long, ends here and the Deschenes rapids begin. Conroy Island divides the stream and the channel between the island and the mainland was utilized at a forebay, water being taken at the level of the lake above and discharged below the rapids after dropping ten feet to the turbines.

This company which began operations in 1896 is now controlled by the Canadian Pacific Railway Company.

DESCHENES ELECTRIC COMPANY.

About 1892 this company, which receives its power supply from the Hull Electric Company, just described, stretched three armored cables across the river to a point near the centre of the city of Ottawa. Power was taken from the Deschenes power house by pole line about six miles and delivered to the cables at 2,200 volts. At the Ottawa end the cables were buried along the bank of the Rideau Canal to the Russell House, which hotel and the Russell Theatre adjoining, are lighted by this company. It did not extend its operations further, having no franchise to use the city streets.

THE OTTAWA POWER COMPANY.

This company commenced operations in 1900. It was organized for the purpose of supplying electrical energy to the Ottawa Carbide Company, Limited, whose extensive works for the manufacture of calcium carbide are situated within a few hundred yards of the power house of the former company in the city of Ottawa. The power house is a substantial stone building with metal roof and steel frame ; the box flumes for the turbines, the foundations and arched tail race are all built of heavy masonry. There are two pairs of 60 inch "Leffell" wheels submerged, operating under about 30 ft. head ; their horizontal shafts pass into the power house where they are direct-connected to two revolving field A.C. generators of 1500 K.W. The generators are single phase, 2200 volts, 60 cycles. The two exciters are connected to extensions of the generator shafts. Novel features in this station are that the exciters furnish current at 250 volts, are much larger than necessary for exciting purposes, and that they also furnish current for the operation of all the motors required in the carbide factory. All these machines are of "Canadian General" manufacture.

The switchboard is mounted on a gallery overlooking the machinery.

The regulation of speed is accomplished by means of "Lombard" governors.

At the carbide factory oil cooled transformers are used to step down to about 75 volts, at which pressure current is delivered to the furnaces. This plant is operated at full load day and night.

CAPITAL POWER COMPANY.

This company with power station at Deschenes, using practically the same water power development as the Hull Electric Company just described, commenced operations in 1901 and at the present time sells its entire output to two customers only, for manufacturing purposes, viz :—The E. B. Eddy Co., who are extensive manufacturers of paper, pulp, matches, pails, tubs, etc., in the city of Hull, Quebec and The Geo. Matthews Co., a large pork packing establishment in the same city. The former company employs water power and steam as well as electricity in the operation of its several factories.

The power house of the Capital Power Co. is L shaped. The power house proper being at the centre and the two wheel houses forming the arms.

The wheel houses, each about 150 x 30 feet, are built of steel frame with concrete foundations and walls, and metal roof. The power house, a building about 75 x 35 feet is of brick with steel framework on concrete foundations, with roof of metal, over asbestos. One wheel house contains 5 turbines, the other 6. All turbines are 61 inch "Trump" vertical wheels submerged in concrete box flumes and geared, by crown wheel and pinion, to horizontal shafts. 5 Wheels in each wheel house are connected to one shaft which extends through the wall into the power house. The odd wheel drives a countershaft to which the exciters are belted.

There are two generators direct connected to the horizontal shafts. They are of "Canadian General" manufacture, A. C. 3 phase, revolving field, 500 K. W. generators operated at 10,000 volts and 60 cycles and running at 180 r. p. m.

There are 3 exciters, 2 of "Canadian General" and one of "Westinghouse" manufacture all of 17 K. W.

The turbines are controlled by "Woodward" governors of the horizontal and friction type. The working head of water is 10 feet. The switchboard consists of generator, feeder and exciter, marble panels. All high tension apparatus is mounted on framework back of these panels, the oil switches being housed in separate compartments of brick and concrete.

The transmission line is about 6 miles long, it consists of two triangular lines of No. 2 bare hard drawn copper wire strung on 40 ft. cedar poles, one line on each side of pole, and attached to large "Imperial" porcelain insulators. The sides of the triangles are about 22 inches.

At Hull there are 3 transformer houses where the voltage is reduced to 420 volts. One at the works of The Geo. Matthews Co., where a 100 H. P. Induction Motor operates a refrigerating plant, contains 3-50 K. W. air-blast transformers and two houses at the works of The E. B. Eddy Co. containing each 3-250 K. W. oil-filled and water-cooled transformers supplying current to 10 or 12 induction motors varying in size from 10 to 300 H. P.

THE OTTAWA AND HULL POWER AND MANUFACTURING COMPANY, LIMITED.

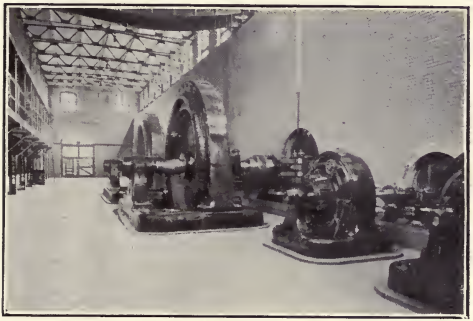
In 1902, the above company began to supply electrical energy to "The Consumers Electric Company, Limited", of Ottawa. Its purposes are to supply power in large quantities to manufacturing or supply companies and to engage in manufacturing.

The Power House, situated in Hull just across the river from Ottawa was designed for five generating units of 1,500 K. W., three of which are now installed. It is a substantial and roomy stone building containing the electrical machinery, water wheel governors and the switchboard which is mounted on a gallery.

The turbines are placed just outside the building in covered flumes, or penstocks built of concrete.

Each wheel unit consists of four "New American" turbines of a capacity of 600 H. P. each, mounted on one horizontal shaft, which extends into the power house.

The wheels operate under 27 ft. head, discharging water into two steel draft tubes for each unit. There are also two independent turbines direct-connected to two exciters, either of which is capable of exciting five 1,500 K. W. generators. The generators are "Canadian General" revolving field machines A. C. 2,300 volts, 60 cycles, 2 phase.



Interior Power House Ottawa and Hull Power & Mfg. Co., Ltd.

THE CONSUMERS ELECTRIC COMPANY.

This company which entered the field of electric light and power supply in the city of Ottawa in 1902, secured its power from the Hull and Ottawa Company just described. It has, therefore, no power house but a distributing station in the centre of the city, where power is received from aerial lines and led to a marble switchboard from which it is distributed.

The building is of brick and concrete, and has a cable tower, current for lighting is distributed to the street lines without transformation at about 2200 volts, single phase. The power circuits are two phase, 2200 volts. Provision is also made for direct current distribution at 500 volts for power through motor-generator sets.

The Canada Atlantic Railway running from Georgian Bay on Lake Huron in the west to the state of Vermont, in the east, has its headquarters in this city where extensive carbuilding and repair shops are situated. Mr. J. R. Booth, a large manufacturer of lumber and pulp, and the principal owner of this railway, has installed at the Chaudiere Falls where his mills are situated, a generating plant of 1000 K. W., consisting of two A.C., 3-phase generators from which current is carried on a pole line along the railway line at 4000 volts, about 4 miles to the railway shops where it is used to operate all shop machinery through induction motors.

All electrical distribution in this district, whether in country or in city, is carried over aerial lines on cedar poles, except in a few streets in Ottawa where the electric railway overhead system is attached to iron poles. There is no underground transmission except that of the Bell Telephone Company, whose trunk cables are in a few streets, buried in creosoted wood conduit with brick manholes at intersections of streets.

The city of Ottawa, which, besides its being the capital of the Dominion of Canada, has the additional advantages of almost unlimited water power in its immediate neighbourhood, of being a great centre for the lumber industry, of having many railway lines centering in itself and of being on the path of the proposed great new waterway from the North West. The "Georgian Bay Canal" should in the, not very distant future, attract many manufacturing industries, and become a city of great wealth and importance.

Electrical Development in the Niagara District.

THE Niagara Peninsula, so long known as the "Garden of Canada," with the advent of cheap electric power from Niagara and vicinity, is without doubt destined to blossom forth industrially.

Within transmitting distance of Niagara from Toronto on the north to London on the south, bounded by the main line of the Grand Trunk Railway to Sarnia, are scattered twenty-nine towns of over 2,000 inhabitants, aggregating in all about half a million of people. With the advantage of cheap power from Niagara, the industries already centered at these places should be greatly enlarged. In addition—this district is gridironed already with steam and electric railways, and there seems to be little doubt that in future all of the local freight and passenger service will be done by means of power transmitted from the Falls.

The farming country in this district is especially suited for market gardening and fruit raising, and it is only necessary to visit the Niagara Peninsula in the Autumn to see there one of the finest fruit raising centres in the world. For this class of commodity the electric railway giving rapid and frequent communication between the cities and the country districts is eminently suited, and, already several electric roads are operating, which make a specialty of and derive a large revenue from the haulage of farm products, and especially fruits.

The Municipalities in this district have recently entered into an agreement, and have empowered a Commission to investigate the whole question of the demands for power in the Peninsula, the sources of supply, the feasibility of transmitting to the various municipalities, and the prices at which power can be sold, not only to the

municipalites themselves, but to the manufacturing concerns within their boundries.

This commission has been given wide powers by the Ontario Government, and it is expected that their report will be in the hands of the Municipalities before the end of the year.

This Commission was appointed in view of the large developments of power now under way at Niagara, and the co-operation of the Municipalities was desirable in order that the best possible arrangements for power for all might be made either with the companies which are already constructing works, or, if necessary, by developing a municipal power scheme with a hydraulic plant either at Niagara or somewhere else in the Peninsula, where abundant power is available.

Cascade and Launching of a Crib.

There are three large power developments under way at Niagara Falls at the present time. These obtained concessions from the Ontario Goverment, by paying certain rentals per horse power year to the Government for the use of water, safe guarded by a minimum payment clause, and they are under certain obligations to the

Queen Victoria Niagara Falls Park Commissioners, on whose lands their plants are situated, to maintain the Park in its present condition as a Park, without disfigurement, their whole construction of power houses, dams and pipe lines, and tranmission lines in the Park being subject to the approval of the Commissioners.

The Park Commission was established by the Ontario Government for the purpose of guarding the interests of the public in the scenic beauties of Niagara, and they have succeeded not only in this, but also in rendering it commercially possible to develop power in abundance without sacrificing those interests, although the works of the power companies are situated in the midst of the Park.

The three companies whose works at the present nearing completion at Niagara Falls, are The Canadian Niagara Power Company, The Ontario Power Company, and The Toronto and Niagara Company (Electrical Development Company of Ontario).

These are given in the order in which their franchises were obtained.

The Canadian Niagara Power Company, although organized as a separate company, is working in conjunction with The Niagara Power Company on the American side of the Falls, and their construction and methods of operation have been developed from the experience of that Company.

They are now constructing works in the Queen Victoria Niagara Falls Park above the Horshoe Falls, designed for a capacity of 110,000 horse rower. The general design is similar to that of Power House No. 2 of The Niagara Falls Power Company now in operation on the United States side of the river.

The tailrace which is just completed, is 2,200 feet long and of a horseshoe form, 25 feet high and 19 feet wide, being lined with 17 inches of concrete with vitrified brick facing. The grade of this tunnel is 7 feet per 1,000 which will give a speed of water when plant is in full operation of about 27 feet per second.

The head canal has a clear waterway 15 feet deep and 250 feet wide, and is crossed by a five span stone arch bridge which carries the tracks of the Niagara Falls & Park Railway, a carriage way, and a sidewalk. This canal widens into a forebay 600 feet wide, extending the whole length of the Power House.

Protection from ice is afforded by (a) an outer ice rack along river face; (b) line of submerged arches forming outer wall of forebay room; (c) a fine ice rack extending the whole of the power house inside the forebay room and immediately outside the penstock mouthpiece; (d) overflow wire which can be used in combination with

floating booms to throw floating materials back into the river again by means of sluiceway channel.

The wheelpit is 165 feet deep, 18 feet wide inside, of brick lining, and 570 feet long.

The turbines, each of a capacity of 12,500 horse power, were designed by Messrs. Escher, Wyss & Company, of Zurich, Switzerland, and are of the twin Francis Vertical type, inward discharge, two draft tubes to each unit, discharging into the open tailrace below. Three of these units are being manufactured and installed by this firm, and two units on the same design by I. P. Morris Company, Philadelphia.

The generators, each of 10,000 horse power, are of the internal revolving field type, and will generate alternating three phase current, 25 cycles, at 12,000 volts. Five of these are being installed by the General Electric Company. The generator and turbines are direct connected by a vertical shaft and will revolve at 250 r. p. m.

The auxiliary machinery consisting of exciter, turbines, exciters, water pumps, oil pumps and oil tanks, etc., are located in three chambers built into the side of the wheel pit 100 feet beneath the surface. This machinery will all be operated by an independent water service drawn from the canal above.

The power house building, for five units, is being constructed of queenstone, limestone, roofed with tile, and has installed two 50 ton electric cranes for service in installation of machinery. The power house will be lined inside with mottled buff brick, enamel brick and marble.

Underground conduits are being constructed from power house to upper arch bridge with a capacity of 75,000 horse power, and from power house to a transformer station situated south and outside of Queen Victoria Park for a capacity of 50,000 horse power.

A transformer station, equipped with water cooled transformers, has been constructed of a present capacity of 25,000 horse power. It will be supplied with water for cooling purposes from pumps located in chambers of wheelpit; there will also be a standpipe carrying one

day's supply of water to be drawn upon in case of accident to this pumping system.

The Toronto and Niagara Company expect to find their chief consumption in the city of Toronto ; their construction is to be upon similar lines to that of the Canadian Niagara Power Company, having a wheelpit 158 feet deep by 416 feet long excavated in the solid rock, and the discharge of water therefrom effected by a low level tail race tunnel rnnning under the centre of the bed of the river discharging directly under the centre of the Horseshoe Falls.

This development throughout is one of the most daring pieces of hydraulic engineering ever contemplated for, while ordinary engineering difficulties are met throughout the work, those encountered in connection with the gathering dams and head race, and the discharge portal underneath the centre of the Falls are such as to appal the most courageous engineer. The most difficult work however has been successfully accomplished in connection with the gathering dam, which diverts the water to the wheel pit ; as a part of this work was constructed in 28 feet of water in rapids immediately above the Falls. This dam changes the original rapids in front of the power house into a pond of still water, approximately 18 feet higher than the original level. Special precautions were taken to prevent ice troubles, and the experience of the companies operating on the American side of the river have been taken into account in preparing of the plans. The Engineers have been assisted somewhat in this respect by the point of land immediately above the intake, which will have a tendency to divert large masses of ice away from the works.

The wheels of which there will be 11 of 12,500 horse power operating under a head of 143 feet, drive through their vertical shafts 10,000 horse power, 25 period generators.

The vertical shafts attached to these turbines have a length of 115 feet, and are supported at three intermediate points by bearings placed on solid masonry.

The tailrace tunnels at the power house are in duplicate, the two races eventually joining and emptying through one discharge tunnel, thus practically making two power houses, admitting of each half of the power house to be operated independently ; this will allow of inspection being made without shutting down the entire power house ; by this means the turbines can be readily inspected. At the discharge of this tailrace channel, consideration had been given to the fact that the Horseshoe Falls are continually receding, and lining rings 6 feet in length each are provided for a distance of 300 feet from the lower end in order that, as the Falls recede, these rings may drop off one by one. On the basis of 125,000 H. P., developed, and an efficiency of 75%, the requirements of this plant will be 70,000 cubic feet of water per minute. The generators and station equipment are supplied by the Canadian General Electric Company of Toronto, Ont.

This Company has purchased a transmission right of way 80 feet wide, from Niagara Falls to Toronto, where a large part of the power will be disposed of. It is the intention to transmit at about 60,000 volts, the wires being placed on steel structures about 400 feet apart, and over this right of way it is anticipated that an electric railway will be constructed.

The Ontario Power Company has adopted a different method of dealing with the hydraulic part of their plant, for, whereas, the other two companies have excavated wheel pits and discharged their tailwater through long tunnels. The Ontario Company has reversed this method and are bringing the water from Dufferin Island in 18 foot steel pipes, buried underneath the ground, and delivering this water at their power house situated below the Falls in the Gorge, discharging their tailwater into the river immediately below the power station. Their head works has an ultimate capacity of 200,000 horse power, and this is nearly finished.

One 18 foot pipe 6,000 feet long is being constructed, at present and has a carrying capacity of 60,000 horse

power. When the 60,000 is exceeded, another pipe of different shape and larger capacity will be laid. The total amount of power which they are privileged to take under terms of their contract is 100,000 horse power.

At DeCew Falls between Niagara and Hamilton is located the power station of the Hamilton Cataract Power Light & Traction Company. This plant has been in operation for some time and is being extended at the present. The power is chiefly used in the City of Hamilton for the supply of the city lighting and power and for operating machinery, electric railways, etc., which centre there.

Hamilton is rapidly becoming an industrial centre and owing to its favorable location as a shipping point both by lake and rail and by reason of the cheap power available from the Cataract Power Company at the present and from Niagara in the future, there seems to be little doubt that it will become the Birmingham of Canada.

The Cataract Power Company takes its water from the Old Welland Canal through a weir built for the purpose by them under contract with the Dominion Government. It passes thence through about one half mile of canal of rectangular section 40' x 9'. At the lower end of this canal is a bridge and measuring weir discharging into a lake now under process of construction. The water carrying capacity at this point amounts to about 1,200 cubic feet per second. After discharging from the measuring weir water enters a series of basins or lakes formed by damming up two ravines by means of heavy earthen embankment construction, the area of which lakes amounts to 409 acres at mean water level. The depth of water varying from 8 feet immediately below the measuring weir down to about 40 feet at the lower dam. Neither of these dams have provision for overflow, this being cared for by a large spillway placed near the forebay on the brow of the escarpment. These lakes formed within two ravines parallel to one another, are connected by a section of canal 1,000 feet in length, capable of carrying

2,000 cubic feet of water per second at a velocity of two feet per second. Immediately at the lower end of the second basin, which is within 300 feet of the brow of the escarpment, the Company are constructing a forebay consisting of a steel and concrete dam through which six penstocks with an internal diameter of 6'6" pass, with the usual provision of stop-logs, checks, safety gates, etc. for the mouth of each penstock separately. These penstocks extend horizontally about 200 feet, then dipping from the brow of the escarpment resting their entire length upon concrete piers with an iron saddle for proper rest at each pier. No provision is made in the pipes for expansion and contraction due to temperature variations. The length of the pipes is 800 feet each, and the temperature range will be 40 degrees in the course of a year. These pipes each supply 1-6300 H. P. single runner double discharge turbine, which turbine is connected to 1-5000 K.W. 3 phase revolving field 2400 volt 66⅔ period generator excited by 2 water driven 40 K. W. exciters, and 4-100 K.W. induction motor driven exciters with storage battery, and connected to exciting houses. The old part of the power house contains 2-SKC inductor alternators of 1,000 K.W. each, and 2-CGE. 2,000 K. W. alternators all directly connected to suitable water wheels, 2 of 1,600 H. P., each by Stillwell-Bierce Co., of Dayton, Ohio, and 2 of 3,300 H. P., each by A. Riva-Moneret, of Milan, Italy.

The present equipment of transformers consists of 10-400 K.W. and 10-200 K.W. oil insulated water-cooled SKC tratsformers with the usual controlling and protective devices, and transforming from 2,400 primary to 22,500-45,000 volts for transmission purposes, delta connected at both ends. An addition will contain 13-2,500 K.W. transformers of the same general description as the smaller ones, and made by the Westinghouse Electric & Mfg. Co. The lines consist of No. 1 line of 3-380,000 circular Mil aluminum cables arranged in 44 inch equilateral triangles and supported by R. Thomas & Sons' 9 inch 45,000 volt swamp-type insulators with locust pins.

Lightning protection is attempted by means of barbed wire stretched in the centre of the triangle. No. 2 line consists of 6 No. 3-0 copper conductors arranged in two right angle triangles with 36 inch base and perpendicular, and with these arrangements they expect a voltage distortion due to this unsymetrical arrangement not to exceed 3% with full non-inductive load, and to be noticeable with their ordinary load connected to this line.

The transforming station includes Beamsville 50 K.W., Grimsby 280 K.W., Imperial Cotton Co., Hamilton, 550 K.W., sub station "B" Hamilton 12,000 K.W., all equipped with oil insulated natural cooled transformers, transforming from high tension 3 phase to 2,400 volt 2 phase. The transforming ratios making a correction for 10% line loss. The principal sub station, Victoria Ave., Hamilton, contains 8,000 K.W. step-down transformers for serving rotaries and distributing service, 3-300 K. W. 66 cycle Westinghouse rotaries; 1-400 ampere 550 volt storage battery of chloride accumulator type; 1-200 K.W. motor generator for 250 volt elevator service, 5-100 light C.G.E. arc lighting tubs of 7½ ampere capacity; 2-1000 K.W. 100 revolution 2 phase 2,400 volt 66⅔ cycle Westinghouse alternators feeding 2,400 volt 2 phase distributing circuits, and operating in parallel with the Water Power House. These alternators are directly connected to 26" x 52" x 42" 100 revolution Goldie & McCulloch cross compound engines operated non-condensing, and supplied with steam by 4-502 H.P., 165 lb. pressure stirling boilers. Boilers are supplied with induced draft, the fans being driven by steam engines.

The Company operates practically all the factories in the city of Hamilton. It also owns and operates the Hamilton Radical Electric Railway, Hamilton Street Railway, and Hamilton and Dundas Street Railway. The City street arc lighting and commercial lighting; lighting of the cities of Dundas, Burlington, Hamilton Beach, Hamilton, Grimsby and Beamsville. and supplies power to the local company, furnishing light and power in the city of St. Catharines.

ACKNOWLEDGEMENTS

The Local Reception Committee is especially indebted to the following interests and persons for the extension of courtesies and assistance.

City of Montreal.
Grand Trunk Railway System.
Bell Telephone Co.
Wire and Cable Co.
Montreal Street Railway Co.
Bank of Montreal.
Canadian Westinghouse Co., Ltd.
Allis Chalmers Bullock Ltd.
Montreal Light, Heat & Power Co.
Shawinigan Water & Power Co.
Quebec Jacques Cartier Electric Co.
Quebec Railway, Light & Power Co.
Frank Redpath, Esq.
Sir George Drummond.
Sir William McDonald.
Canadian Pacific Railway Co's Telegraph.
Sovereign Bank.
Great Northern Railway of Canada.

CANADA TAG & LABEL PRINTING CO., LTD.
MONTREAL.

8A5

THE LIBRARY
UNIVERSITY OF CALIFORNIA
Santa Barbara

THIS BOOK IS DUE ON THE LAST DATE
STAMPED BELOW.

Series 9482

UC SOUTHERN REGIONAL LIBRARY FACILITY
A 000 587 511 7